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Floristic composition and ecological parameters of weeds in corn (*Zea mays* L.), in Tosagua, Ecuador

Composición florística y parámetros ecológicos de arvenses en maíz (*Zea mays* L.), en, Tosagua, Ecuador

Composição florística e parâmetros ecológicos de ervas daninhas em milho (*Zea mays* L.), em Tosagua, Equador

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Abstract

Corn is one of the most important species worldwide due to its uses for feeding humans and animals. In Ecuador, the province of Manabí is considered the area with the largest cultivated area nationwide. This work aimed to characterize weeds' floristic composition and predominance in El Junco, Tosagua corn production systems. To estimate the dominance of existing weeds, 10 farms were selected, where thirty random samplings were carried out for each farm using a 0.50 x 0.50 m quadrant. At each sampling point, the existing weeds and their respective identification were counted. In total 39 species were identified, 32 belonging to the Magnoliopsida class (dicotyledons) and 7 to the Liliopsida class (monocotyledons) and grouped into 16 botanical families. The families with the greatest representation were: Poaceae (25,06 %), Euphorbiaceae (18,61 %), Cyperaceae (14,79 %), Asteraceae (9,76 %) and Malvaceae (8,49 %). The most frequent species were *Urochloa fasciculata*, *Euphorbia hirta*, *Cyperus rotundus*, *Cyanthillium cinereum*, *Richardia scabra*, *Corchorus hirtus* and *Alternanthera* sp. The species *U. fasciculata*, *E. hirta,* and *C. rotundus* obtained the highest dominance values with 3.88, 3.49, and 3.03 % respectively. In this way, we concluded that the Poaceae family, presented the greatest number of weeds in the corn production systems in the El Junco locality. Adequate knowledge of the floristic composition of an agroecosystem will allow the development of appropriate weed management strategies in different commercial corn fields.

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Resumen

El cultivo de maíz, tiene una importancia mundial muy alta debido a sus múltiples usos principalmente en la alimentación de humanos y animales. En Ecuador, la provincia de Manabí se considera como la zona de mayor área cultivada a nivel nacional. El presente trabajo tuvo como objetivo determinar la composición florística y parámetros ecológicos de plantas arvenses en el cultivo de maíz en el Junco, Tosagua, Ecuador. Para estimar la dominancia de las arvenses, se seleccionaron 10 fincas, estableciendo 10 puntos de muestreo por cada unidad de producción. Cada muestreo comprendió un área de 0,25 m^2. Para realizar el conteo y la determinación taxonómica de las arvenses. En total se determinaron 39 taxones, 33 especies y 6 a nivel de género, 32 pertenecientes a la clase Magnoliopsida (dicotiledóneas) y 7 a la clase Liliopsida (monocotiledóneas) y agrupadas en 16 familias botánicas. Las familias con mayor representatividad fueron: Poaceae (25,06 %), Euphorbiaceae (18,61 %), Cyperaceae (14,79 %), Asteraceae (9,76 %) y Malvaceae (8,49 %). Las especies más frecuentes fueron *Urochloa fasciculata, Euphorbia hirta, Cyperus rotundus, Cyanthillium cinereum, Richardia scabra, Corchorus hirtus* y *Alternanthera* sp. Los promedios más altos de dominancia fueron alcanzados por las especies *U. fasciculata, E. hirta* y *C. rotundus* con 3,88; 3,49 y 3,03 % respectivamente. De esta forma, se concluye que la familia Poaceae, presentó el mayor número de arvenses en los sistemas productivos de maíz en la localidad El Junco. El adecuado conocimiento de la composición florística de un agroecosistema, permitirá elaborar estrategias adecuadas de manejo de arvenses en los diferentes campos comerciales de maíz.

Palabras clave: fitossociologia, vegetación, inventario florístico.

Resumo

O milho é uma das espécies mais importantes do mundo, devido às suas utilizações na alimentação humana e animal. No Equador, a província de Manabí é considerada por ter a maior área cultivada em todo o país. O objetivo deste trabalho foi caracterizar a composição florística e a predominância de ervas daninhas nos sistemas de produção de milho em El Junco, Tosagua. Para estimar a dominância de plantas daninhas foram selecionadas 10 fazendas, onde foram realizadas trinta amostragens aleatórias para cada fazenda, utilizando um quadrante de 0,50 x 0,50 m. Em cada ponto amostral foram contadas as plantas daninhas existentes e sua respectiva identificação. No total foram identificadas 39 espécies, sendo 32 pertencentes à classe Magnoliopsida (dicotiledôneas) e 7 à classe Liliopsida (monocotiledôneas) e agrupadas em 16 famílias botânicas. As famílias com maior representatividade foram: Poaceae (25,06 %), Euphorbiaceae (18,61 %), Cyperaceae (14,79 %), Asteraceae (9,76 %) e Malvaceae (8,49 %). As espécies mais frequentes foram *Urochloa fasciculata*, *Euphorbia hirta*, *Cyperus rotundus*, *Cyanthillium cinereum*, *Richardia scabra*, *Corchorus hirtus*, *Alternanthera* sp. Os maiores valores de dominância foram obtidos pelas espécies *U. fasciculata*, *E. hirta* e *C. rotundus* com 3,88, 3,49 e 3,03 % respectivamente. Desta forma, conclui-se que a família Poaceae apresentou o maior número de plantas daninhas nos sistemas de produção de milho na localidade de Tosagua. O conhecimento adequado da composição florística de um agroecossistema permitirá o desenvolvimento de estratégias adequadas de manejo de plantas daninhas em diferentes lavouras comerciais de milho.

Palavras chave: fitossociologia, vegetação, registro florístico.

Introduction

Weeds, also incorrectly referred to as ‘unwanted plants’, are plants that grow in undesirable locations, interfering with land and water use and negatively affecting crop development (Chandrasekara *et al*., 2010; Zandoná *et al*., 2018). These plant species exhibit high competitiveness and adaptability to different environmental conditions (Majeed *et al*., 2022), as well as more efficient reproductive strategies than those of crops, notably producing abundant seeds, most of which are small in size, which contributes to an increase in the soil seed bank (Romaneckas *et al*., 2021; Pinke *et al*., 2022).

Compared to cultivated plants, weeds tend to germinate earlier and exhibit rapid growth regardless of climatic conditions (Chandrasekara *et al*., 2010). Their presence can cause significant losses in agricultural yield, depending on the level of infestation (Melo *et al*., 2019). These losses can affect both the quality (Majrashi, 2022) and the volume of the harvested crop, with losses ranging from 45 to 95 % in horticultural crops (Mennan *et al*., 2020) and up to a 21 % reduction in maize production (Ngawit *et al*., 2024).

Traditionally, weed management has been carried out mainly through mechanical and cultural methods (Majrashi, 2022); however, these are not always effective. Globally, chemical control through the use of herbicides has gained prominence due to its efficiency across various crops, with herbicides being used predominantly in developed countries (Chauhan, 2020). In this context, the global herbicide market reached a sales volume of $40.16 billion, with sales estimated at $45.42 billion and $72.64 billion for 2024 and 2028, which would represent approximately 59.1 % of global pesticide sales (The Business Research Company, 2023, 2024).

The cultivation of maize (*Zea mays* L.), one of the most important grasses worldwide, faces considerable pressure from the diversity of weed species. These pose a threat to crop development through interference (competition + allelopathy) and by acting as hosts for pests and diseases (Suárez-P *et al*., 2018). In 2023, global production reached 1.23 billion metric tonnes, representing a 6 % increase compared to 2022 (Food and Agriculture Organization of the United Nations [FAOSTAT], 2024; Department of Agriculture [USDA], 2024). Among the top-producing countries, the United States (38.69 MMT), China (288.84 MMT), Brazil (122 MMT), Argentina (52 MMT) and India (37.5 MMT) rank in the global top five respectively (USDA, 2024).

In Ecuador, the area planted with dry hard maize reached 344,272 ha, with a production of 1.64 million tonnes and a national average yield of 4.4 $t.ha^{-1}$, grown mainly in the provinces of Manabí, Los Ríos and Guayas. Manabí established itself as the leading national maize producer, with an area of 119,130 ha and 467,270 tonnes produced, at an average yield of 4.22 $t.ha^{-1}$ (Agricultural Public Information System [SIPA], 2024). This production is mainly generated by small and medium-sized producers on commercial fields established on rainfed land (rainy season) in areas with sloping topography. Despite being rainfed, this production contributes significantly to national output, with a large percentage destined for agribusiness.

Along the Ecuadorian coast, several weed species associated with this crop have been identified, including the following: pigweed (*Amaranthus* spp.), cocklebur (*Bidens pilosa* L.), Bermuda grass and/or virgin grass (*Cynodon dactylon* L.), coquitos / cortaderas (*Cyperus* spp.), digitaria (*Digitaria sanguinalis* L.), barnyard grass (*Echinochloa colona* L.), morning glories (*Ipomea* spp.), bitter melon (*Momordica charantia* L.), barnyard grass (*Leptochloa* spp.), Paspalum (*Paspalum fasciculatum* L.), fork grass (*Paspalum conjugatum* L.) and broomrape (*Sida* spp.) (Amaya *et al*., 2018).

The various ways in which weeds affect crops, combined with the importance of maize cultivation, suggest a scenario in which these undesirable plants play a significant role in global maize production, potentially posing a major threat on a global scale. Globally, it has been estimated that uncontrolled weeds can cause losses of between 8.6 % and 51 % of maize yield (Gharde *et al*., 2018). In Ecuador, although there are few studies on losses attributable to weeds, losses due to weed interference are estimated at up to 45 % of production (Martínez *et al*., 2021). With this in mind, the accurate taxonomic identification of weeds present in commercial crops forms the basis for establishing appropriate management measures, which must be economically viable and environmentally safe (Garibaldi-Márquez *et al*., 2022; Rad *et al*., 2020).

In view of the above, the objective of this study was to characterise the floristic composition and ecological parameters of weeds in maize crops in Tosagua, Ecuador.

Materials and methods

Study area

The research was carried out between March and August 2020 in the 'El Junco' sector of the Tosagua canton, in the province of Manabí, Ecuador, within the geographical coordinates: 00°49'16'' S, 80°19'13'' W and at an altitude of 80 metres above sea level (Figure 1).

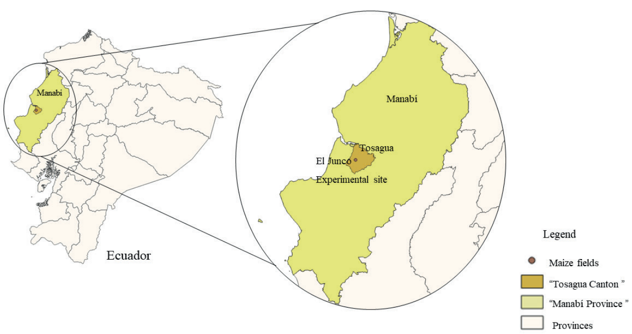

Figure 1. Geographical location of the study area: El Junco, Tosagua-Manabí, Ecuador

Sample collection and sampling technique

The sampling areas were determined through reconnaissance surveys on representative farms, where 10 maize-producing farms were selected to collect data on flora and ecological parameters, with an average size of between 4 and 10 ha per farm. The sampling pattern was carried out uniformly in the central area of the maize fields during the dry season, following a zigzag route. To avoid the edge effect, a distance of 20 m was established from the field boundary into the crop before sampling began.

The number of samples per plot consisted of 30 sampling sites. Each sampling site was represented by a 0.25 m² quadrant (0.5 m × 0.5 m). Samples were collected between 80 and 100 days after sowing, in each of the selected plots, when the weed communities had reached physiological maturity. The collected specimens were placed in labelled plastic bags, with a unique code assigned to each sample. The samples were then transported to the laboratory for analysis and taxonomic identification.

Taxonomic identification of weeds

The collected weed specimens were analysed and identified at the order, family, genus and species levels, using information from physical herbaria (Technical University of Manabí), digital platforms (Royal Botanic Gardens, Kew, https://www.kew.org/; Conabio Virtual Herbarium, http://www.conabio.gob.mx/otros/cgi-bin/herbario.cgi and New York Botanical Garden, https://www.nybg.org/), as well as specialised taxonomic literature (World Flora Online list, https://www.worldfloraonline.org/), enabling identification down to species level.

Vegetative characterization

Phenotypic diversity

The total number of broad-leaved and narrow-leaved weed species per m² was recorded.

Phytosociological indicators

With regard to phytosociological indicators, the following variables were used: density, dominance, frequency, abundance, relative frequency, relative density, relative abundance, importance value index and relative importance index (Table 1).

Table 1. Description of phytosociological parameters with their formulas

Parameters	Formulas
Density (D)	Total number of individuals per species/Total area surveyed
Dominance	Total number of individuals sampled of species i/ total number of individuals of all sampled species
Frequency (F)	Number of plots containing the species/Total number of plots used
Abundance (A)	Total number of individuals per species/Total number of plots containing the species
Relative frequency (RF)	Frequency of species × 100/Total frequency of all species
Relative density (RD)	Density of the species × 100/Total density of all species
Relative abundance (RA)	Species abundance/Total abundance of all species
Importance value index (IVI)	RF + RD + RA
Relative importance index (RII)	Species-specific RII × 100/Total RII for all species

Source: (Braun-Blanquet, 1979)

Data analysis

The data generated from the weeds present on maize-growing farms were analysed using the formulas set out in Table 1 above and through descriptive analysis.

Results and discussion

Taxonomic identification of weeds

In this study, 1,967 weed specimens were analysed in commercial maize fields in the town of Junco. A total of 39 species were recorded, of which 33 were fully identified and 6 were identified only to genus level; of the identified species, 17 families were represented across all analyzed samples. The predominant families were: Poaceae, Euphorbiaceae, Cyperaceae and Asteraceae. Table 2 details the weeds collected in the Tosagua canton, Ecuador, classified by class, family and species.

Vegetative characterisation of weeds

A total of 39 weed species were taxonomically identified, belonging to 17 families, of which 15 were dicotyledons and 2 were monocotyledons. Within the class Liliopsida, the Poaceae family had the highest number of individuals (493), representing 25.06 %, followed by the Cyperaceae family, which recorded 291 individuals, equivalent to 14.79 % (Table 2).

Meanwhile, in the class Magnoliopsida, the families with the highest number of individuals were: Euphorbiaceae with 366 individuals (18.61 %), followed by Asteraceae with 192 (9.76 %), Malvaceae with 167 (8.49 %), Rubiaceae with 158 (8.03 %) and Amaranthaceae with 129 (6.56 %) (Table 2). These results are similar to various studies conducted on the quantification of weeds associated with crops in tropical and subtropical zones, such as that carried out

Table 2. Floristic inventory of weeds in maize cultivation, collected in El Junco, Tosagua.

Scientific name	Common name	Family	Botanical class
Acnistus arborescens (L.) Schltdl.	Cojojo	Solanaceae	Magnoliopsida
Alternanthera sp.	Jorra	Amaranthaceae	Magnoliopsida
Amaranthus dubius Mart.	Bledo manso	Amaranthaceae	Magnoliopsida
Browallia americana L.	Simpatica	Solanaceae	Magnoliopsida
Capsicum frutescens L.	Ají de ratón	Solanaceae	Magnoliopsida
Corchorus hirtus L.	Espadilla, escobillo	Malvaceae	Magnoliopsida
Cordia lutea Lam.	Muyuyo	Boraginaceae	Magnoliopsida
Cordia sp.	Muñeco	Boraginaceae	Magnoliopsida
Croton lobatus L.	Cola de alacrán	Euphorbiaceae	Magnoliopsida
Cucumis dipsaceus Ehrenb. ex Spach.	Calabacilla	Cucurbitaceae	Magnoliopsida
Cyanthillium cinereum (L.) H. Rob.	Hierba de hierro	Asteraceae	Magnoliopsida
Cyperus rotundus	Coquito	Cyperaceae	Liliopsida
Delilia sp.	Pelusilla	Asteraceae	Magnoliopsida
Desmodium sp.	Pega pega	Fabaceae	Magnoliopsida
Echinochloa colona (L.) Link.	Paja de patillo	Poaceae	Liliopsida
Eleusine indica (L.) Gaertn.	Paja de burro	Poaceae	Liliopsida
Euphorbia heterophylla L.	Lechero	Euphorbiaceae	Magnoliopsida
Euphorbia hirta L.	Hierba de sapo	Euphorbiaceae	Magnoliopsida
Euphorbia nutans Lag.	Lechosa	Euphorbiaceae	Magnoliopsida
Heliotropium indicum L.	Rabo de alacrán	Boraginaceae	Magnoliopsida
Hyptis suaveolens (L.) Poit.	Cordón de fraile	Lamiaceae	Magnoliopsida
Ipomea hederifolia L.	Batatilla	Convolvulaceae	Magnoliopsida
Ipomea sp.	Bejuco	Convolvulaceae	Magnoliopsida
Leptochloa sp.	Paja mona	Poaceae	Liliopsida
Phyla nodiflora (L.) Greene	Bella alfombra	Verbenaceae	Magnoliopsida
Solanum pimpinelifolium L.	Tomatillo	Solanaceae	Magnoliopsida
Momordica charantia L.	Achochilla	Cucurbitaceae	Magnoliopsida
Nicotiana longiflora Cav.	Flor de sapo	Solanaceae	Magnoliopsida
Urochloa fasciculata (Sw.) R. Webster.	Granadilla	Poaceae	Liliopsida
Petiveria alliacea L.	Zorrilla	Phytolaccaceae	Magnoliopsida
Prestonia mollis Kunth.	Malacapa	Apocynaceae	Magnoliopsida
Priva lappulacea (L.) Pers.	Pegador chillador	Verbenaceae	Magnoliopsida
Richardia scabra L.	Sangre de toro	Rubiaceae	Magnoliopsida
Rottboellia cochinchinensis	Paja caminadora	Poaceae	Liliopsida
Senna tora (L.) Roxb.	Retama	Fabaceae	Magnoliopsida
Sida acuta Burm.fil.	Escoba	Malvaceae	Magnoliopsida
Solanum americanum Mill.	Hierba mora	Solanaceae	Magnoliopsida
Sorghum halepense (L.) Pers.	Sorgo de silvestre	Poaceae	Liliopsida
Tridax procumbens L.	Falsa manzanilla	Asteraceae	Magnoliopsida

by Villa *et al*. (2017), which elucidated several aspects inherent to weeds in potato cultivation in the Venezuelan Andes, where it was established that the Asteraceae, Fabaceae and Poaceae were the most representative families.

Similarly, these findings are consistent with those reported by Gámez López *et al*. (2011), who, when characterising the floristic composition of an irrigated maize crop, observed that the families Poaceae and Cyperaceae were the most abundant within the Liliopsida, whilst the class Magnoliopsida was mainly represented by the families Euphorbiaceae, Amaranthaceae and Scrophulariaceae. Similarly, results from another study are consistent with those presented here, where the weeds with the highest number of individuals were *Cyperus rotundus* L. (Cyperaceae) and *Rottboellia cochinchinensis* (Lour.) Clayton (Poaceae) (Blanco and Leyva, 2010).

Ecological indicators

The weeds that prevailed in terms of density and frequency were: *U. fasciculata*, *E. hirta*, *C. rotundus*, *C. cinereum*, *R. scabra*, *C. hirtus*, *Alternanthera* sp. The species *U. fasciculata* had the highest abundance index (3.88 %), followed by *E. hirta* (3.49 %), *C. cinereum* (3.38 %), *C. rotundus* (3.03 %) and *S. tora* (3 %) (Table 3).

With regard to the importance value indices (IVI) of the families, the class Liliopsida had average values ranging from (2.45 %) to (38.73 %), whilst the dicotyledons ranged from (1.4 %) to (35.53 %), with the families Poaceae and Cyperaceae recording the highest IVIs, whilst within the class Magnoliopsida, the Euphorbiaceae, Asteraceae, Rubiaceae, Malvaceae, and Amaranthaceae stood out.

The species *U. fasciculata*, with an IVI of 38.73 %, was the species that stood out among the grasses; that is, this taxon exhibited 12.91 % relative importance. In turn, *E. hirta* had the highest IVI within the Euphorbiaceae family at 35.53 %, and a relative importance index of 11.84 % (Figure 2).

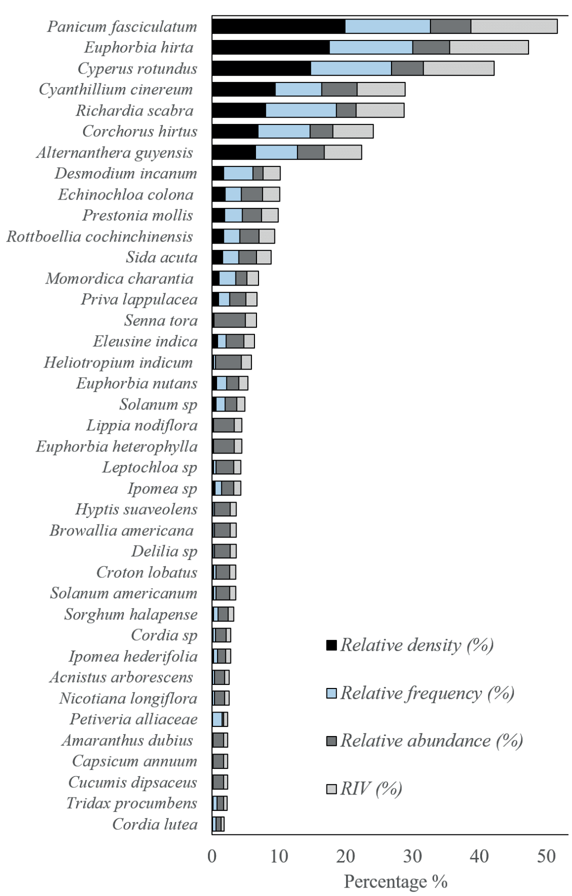

Figure 2. Ecological indicators of weeds in maize crops in Junco, Tosagua.

It is worth noting that *C. rotundus* had an IVR of 10.54 %, which is similar to the findings reported by Oliveira-Canuto & Oliveira-Canuto (2021), who indicated that the Poaceae and Amaranthaceae families were the most prevalent, although they identified *C. rotundus* as the species with the highest Importance Value Ratio.

The development of phytosociological inventories enables the precise identification of weed species, which is of great importance in various types of crops, both annual and perennial (Moura-Filho *et al*., 2015; Santos *et al*., 2016; Almeida *et al*., 2019), as they provide a better understanding of the population characteristics of weeds as well as other associated morphological, growth and reproductive characteristics (Alves Albuquerque *et al*., 2017; Santos *et al*., 2018; Prates *et al*., 2019), as well as the identification of exotic species that could potentially become weeds (Mendes *et al*., 2018). This inventory highlights six species of major importance in tropical zones, which grow in disturbed environments and crop plots, most of which are annual or perennial in growth habit (Vibrans, 2010).

Furthermore, when examining maize cultivation specifically under different production conditions, a high representation of the families Poaceae, Euphorbiaceae, Cyperaceae, Fabaceae and Asteraceae has been reported (Ferreira *et al*., 2019; de Souza Cruz *et al*., 2009; Oliveira *et al*., 2014), which account for the highest numerical values in terms of the number of individuals, frequency, density and abundance, similar to the findings of our phytosociological inventory survey. (Albuquerque *et al*., 2014; Oliveira *et al*., 2014; Salaudeen *et al*., 2022; Tavares *et al*., 2013), highlighting a certain similarity with research carried out in the main producing countries of this grass, such as Brazil (Fontanetti *et al*., 2025) and the United States (Alptekin *et al*., 2023).

Conclusions

On the maize farms at the Junco site, 37 weed species belonging to 17 families were identified, with Poaceae, Euphorbiaceae, Cyperaceae and Asteraceae being the most prevalent; this reflects a high diversity in the floristic composition due to the predominance of these species.

As for the dominance of *U. fasciculata*, *E. hirta*, *C. rotundus* and *C. cinereum*, these showed the highest values for importance, density and frequency. This demonstrates the adaptability of these species to disturbed conditions and plant selection patterns in intensive agricultural systems.

In this context, a proper understanding of the floristic composition in maize production systems becomes a fundamental tool for the timely selection of strategies for the management and/or control of weeds, with the aim of reducing the impact that these plant species have on crop productivity.

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Table 3. Density, frequency, abundance and importance index of weeds associated with maize cultivation in Tosagua, Ecuador.

Scientific name	Density	Frequency	Abundance	Importance index
Acnistus arborescens	0.03	0.01	1.00	1.92
Alternanthera sp.	1.71	0.17	2.56	16.81
Amaranthus dubius	0.01	0.00	1.00	1.74
Browallia americana	0.04	0.01	1.50	2.75
Capsicum annuum	0.01	0.00	1.00	1.74
Corchorus hirtus	1.80	0.21	2.18	18.08
Cordia lutea	0.03	0.01	0.50	1.38
Cordia sp	0.04	0.01	1.00	2.10
Croton lobatus	0.05	0.01	1.33	2.67
Cucumis dipsaceus	0.01	0.00	1.00	1.74
Cyanthillium cinereum	2.48	0.18	3.38	21.68
Cyperus rotundus	3.88	0.32	3.03	31.63
Delilia sp	0.04	0.01	1.50	2.75
Desmodium incanum	0.45	0.12	0.97	7.66
Echinochloa colona	0.52	0.06	2.05	7.59
Eleusine indica	0.23	0.03	1.70	4.79
Euphorbia heterophylla	0.03	0.00	2.00	3.36
Euphorbia hirta	4.61	0.33	3.49	35.53
Euphorbia nutans	0.19	0.04	1.17	4.05
Heliotropium indicum	0.07	0.01	2.50	4.42
Hyptis suaveolens	0.04	0.01	1.50	2.75
Ipomea hederifolia	0.05	0.02	0.80	2.08
Ipomea sp	0.12	0.03	1.13	3.23
Leptochloa sp	0.07	0.01	1.67	3.24
Phyla nodiflora	0.03	0.00	2.00	3.13
Solanum sp	0.16	0.04	1.09	3.54
Momordica charantia	0.28	0.07	1.05	5.23
Nicotiana longiflora	0.03	0.01	1.00	1.32
Urochloa fasciculata	5.23	0.34	3.88	38.73
Petiveria alliacea	0.03	0.04	0.18	1.77
Prestonia mollis	0.51	0.07	1.81	7.41
Priva lappulacea	0.27	0.04	1.54	5.06
Richardia scabra	2.11	0.28	1.88	21.56
Rottboellia cochinchinensis	0.47	0.06	1.84	7.05
Senna tora	0.04	0.00	3.00	4.98
Sida acuta	0.43	0.06	1.68	6.66
Solanum americanum	0.05	0.01	1.33	2.51
Sorghum halepense	0.07	0.02	1.00	2.45
Tridax procumbens	0.04	0.02	0.60	1.72

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