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Study of Weeds in Banana Cultivation in the Comoros Islands

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ABSTRACT

Bananas (*Musa acuminata*) rank fourth in the world in agricultural production after wheat, rice, and maize. They are the most widely grown fruit in the world. However, the presence of weeds is a factor reducing this production. In banana crops, plant biodiversity includes weeds and ground-cover plants. Thus, this study focuses on the inventory and floristic biodiversity of banana crop weeds in three producing islands of Comoros: Anjouan (island 2), Mohéli (island 1), and Ngazidja (island 3). Species identification was carried out systematically using a CD-ROM called Adventol, and various phytosociological parameters were studied. The results revealed the identification of 102 species in 29 families. The island of Ngazidja stands out for its floristic richness, hosting 56 species in 20 families. The highest similarity coefficient was observed between islands 1 and 3, reaching 57.14%. The families with the highest number of weed species are Poaceae (24 species; 23.5%), Asteraceae (12 species; 11.8%), and Fabaceae (11 species; 10.8%). The Jaccard index is significant between Islands 1 and 3, reaching 0.4. Consequently, managers must consider improving weed control methods by adopting new technologies for banana production in Comoros.

Keywords: Banana - Weeds - Biodiversity - Species richness - Comoros Islands.

Introduction

Bananas (bananas and plantains) are the fourth most important agricultural product after wheat, rice, and maize in global production.[1] Despite the undeniable importance of bananas and plantains in the Comoros Islands, several biotic and abiotic factors limit their production, including weeds. The most commonly used means of controlling these weeds is the application of herbicides.[2] Bananas and plantains belong to the Musaceae family[3] divided into three genera: Musella, Ensete, and Musa. The latter genus is widely distributed in the Comoros Islands. Local production of this genus of banana accounts for 85% of consumption, making it an essential element in the food security of African countries.[4] According to 2007 data from the United Nations Conference on Trade and Development, the consumption of bananas reaches 65,000 tonnes per year, an average of 250 grams per capita per day. However, studies on bananas in the Comoros are scarce and incomplete. It is, therefore, essential to predict the evolution of weed communities when setting up new cropping systems.[5] To understand how to manage weeds with little or no herbicides in field crops, studying the harmfulness of weeds, their effectiveness and effects, and their reduction on yield is necessary. This question has been studied for years, but the results often appear contradictory. In addition, there is the problem of the methodology to be used to study such systems.

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The soil seed stock of cultivated plots theoretically represents the potential flora and seems to be the most reliable way to characterize weed communities.[6] Thus, our study consists of identifying weed species invading banana plantations and studying biological indicators.

Materials and Methods

Study area

The Comoros, an archipelago in the Indian Ocean, comprises three islands: Grande Comore, Anjouan, and Mohéli, with a total surface area of 1862 km². Grande Comore (Ngazidja), island number 3, covers 1148 km², while Anjouan (Ndzuwani), island number 2, covers 424 km² and Mohéli (Mwali), island number 1, has an area of 290 km². These volcanic islands are isolated from each other by deep underwater trenches (Figure 1). They are located between latitudes 11°20' and 13°04' South and longitudes 43°11' and 45°19' East, around 300 km east of Mozambique and 320 km northwest of Madagascar.[7]

Sampling methods

The study material used consisted of weeds observed in banana crops on the three producing islands of Comoros. Samples were collected during regular visits (10 visits) to the plots based on specific symptoms recognized as indicators while noting their frequency in relation to leaf area. Sampling was carried out in a stratified fashion so that the plots represented the different environments (soil types and climate) and the different agricultural practices (types of rotation) specific to each region of the Comoros Islands. Samples were selected proportionately to the surface area the different variants identified covered. Species identification was carried out systematically using a CD-ROM (Adventol®) developed by the Center for International Cooperation in Agricultural Research for Development (CIRAD).

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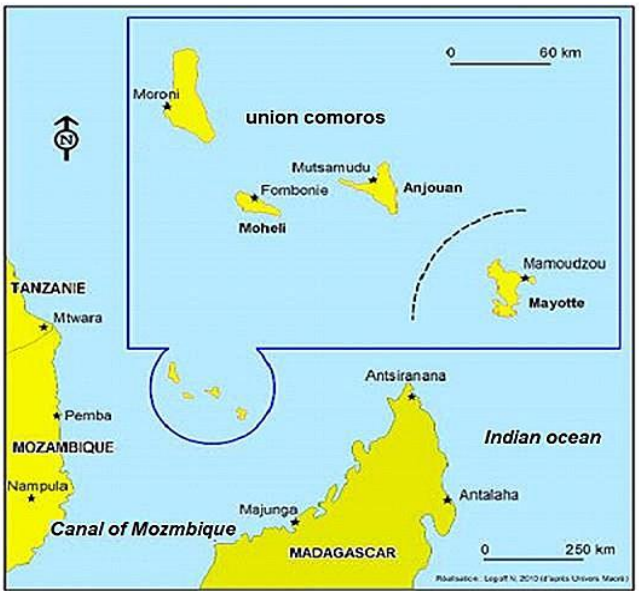

Figure 1: Location map of the Comoros Archipelago.

Phytosociological parameters studied
The parameters studied include:
The specific richness of a given island refers to the number of species (families) present on that island.
The local richness of a vegetation type is calculated by taking the average of the specific richness of the three islands.
The global richness by vegetation type corresponds to the number of species (families) on at least one of the islands.
The original richness of a vegetation type. This is the number of species (families) present exclusively on one island and not on the others.
Species commonality corresponds to the number of species present simultaneously on all three islands.
Coefficient of similarity (Cs): allowed to check the homogeneity of the survey sites taken two by two and expressed as 2c/a+b (with a and b representing the numbers of species (families) counted respectively in two sampling sites, and c the number of species common to both sites.

The Jaccard index quantifies similarity by measuring the extent of species replacement or biotic change along environmental gradients. It enables comparing two sites by evaluating the similarity between the two surveys, considering the species shared by both surveys and those unique to each survey. It is calculated using the following formula:
I = Nc / (N1 + N2) - Nc
Where Nc is the number of taxa common to sites 1 and 2, N1 and N2 represent the number of taxa present at sites 1 and 2, respectively.

Statistical analysis
The data collected was inputted into Excel and then transferred to SPSS for analysis. Qualitative variables were expressed in frequency and Relative Wealth Index.

Results and Discussion

Geographical distribution of banana weeds in the study areas
The inventory of the areas studied made it possible to describe a wealth of 102 species of weeds divided into 29 families (Table 1). The distribution according to the specific richness in families made it possible to classify these weeds into four groups:
Group 1, the most frequent group, is composed of the following families: Poaceae (24 species; 23.5%), Asteraceae (12 species; 11.8%) and Fabaceae (11 species; 10.8%), with an average cover of 15.37% and an abundance coefficient between 1 and 2 according to Van Der Maarel.[8]
Group 2 comprises families whose species are between 4 and 8, with an average coverage of 5.48% and an abundance coefficient between 1 and 2, according to Van Der Maarel.[8] The most common family in this group is Euphorbiaceae.
Groups 3 and 4 are represented by families with a species richness of between 1 and 2, with an average coverage of 1.5% and an abundance coefficient of less than 1, according to Van Der Maarel.[8]
Sociability reflects the distribution mode of species of the same family in relation to each other, with families of so-called isolated species (groups 3 and 4) or families of species in groups 1 and 2.

Floristic richness
The floristic richness of the three islands studied is shown in Table 2. Island 3 has the highest species and family richness, with 54.90% and 45.45%, respectively. Island 2 has a species richness of 19.60% and a family richness of 20.45%, while Island 1 has a species richness of 25.49% and a family richness of 34.09%. However, the (average) local richness of the three islands comprises 34 species in 15 families.

Table 1: Geographical distribution of banana weeds in the 3 islands studied

Species	Common names	Families	Orders	Genera	Island		
					1	2	3
Abutilon asiaticum L.	Mfulera	Malvaceae	Malvales	*Abutilon*	+	-	-
Acalypha indica L.	Mwadjumbe	Euphorbiaceae	Malpighiales	*Acalypha*	-	-	+
Achyranthes aspera L.	Ntsohomaele	Amaranthaceae	Caryophyllales	*Achyranthes*	-	-	+
Ageratum conyzoides L.	Shikoni, Davu, Mnunka	Asteraceae	Asterales	*Ageratum*	-	-	+
Amaranthus dubius L.	Debere	Amaranthaceae	Caryophyllales	*Amaranthus*	+	-	-
Amaranthus viridis L.	Debere	Amaranthaceae	Caryophyllales	*Amaranthus*	+	-	-
Cyclospermum leptophyllum		Apiaceae		*Cyclospermum*	-	-	+
Argemone mexicana L.	Angadi	Papaveraceae	Ranunculales	*Argemone*	-	-	+
Asystasia gangetica L.	Usite	Acanthaceae	Scrophulariales	*Asystasia*	-	+	-
Axonopus compressus (Sw.)	Kunu	Poaceae		*Axonopus*	-	-	+
Bidens pilosa	Mdudu/ Ntsohoho	Asteraceae	Asterales	*Bidens*	-	+	-
Boerhavia diffusa L.	Katsi	Nyctaginaceae	Caryophyllales	*Boerhavia*	-	+	-
Senna obtusifolia (L.)	Dadjile/ Hassa	Fabaceae	Fabales	*Senna*	-	+	-
Senna occidentalis (L.)	Sanamaka	Fabaceae	Fabales	*Senna*	-	-	+
Chenopodium ambrosioides L.	Irudali	Amaranthaceae	Caryophyllales	*Chenopodium*	-	-	+

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Cleome viscosa L.		Brassicaceae	Capparales	*Cleome*	-	-	+
Commelina benghalensis L.	Coha	Commelinaceae	Commelinales	*Commelina*	+	-	-
Commelina diffusa	Nrambantsi	Commelinaceae	Commelinales	*Commelina*	+	-	-
Centrosema pubescens		Fabaceae	Fabales	*Centrosema*	+	-	-
Corchorus olitorius L.		Malvaceae	Malvales	*Corchorus*	+	-	-
Cardiospermum halicacabum L.	Mbabaunandzo/ Kalisso	Sapindaceae	Sapindales	*Cardiospermum*	-	-	+
Crotalaria retusa L.		Fabaceae	Fabales	*Crotalaria*	+	-	-
Clidemia hirta (L.)	Ntrundadzaha/Désiré	Melastomataceae	Myrtales	*Clidemia*	-	-	+
Colocasia esculenta (L.)	Madjimbi	Araceae	Arales	*Colocasia*	+	-	-
Cyathula prostrata (L.)		Amaranthaceae	Caryophyllales	*Cyathula*	-	-	+
Cynodon dactylon (L.)	Nkunundredje	Poaceae	Cyperales	*Cynodon*	-	-	+
Cyperus difformis L.	Ndawe	Cyperaceae	Poales	*Cyperus*	-	+	-
Cyperus esculentus L.	Makunu	Cyperaceae	Poales	*Cyperus*	+	-	-
Courtoisina cyperoides (Roxb.)		Cyperaceae	Poales	*Courtoisina*	-	-	+
Cyperus rotundus L.	Ndawe	Cyperaceae	Poales	*Cyperus*	-	+	-
Desmodium incanum		Fabaceae	Fabales	*Desmodium*	-	-	+
Digitaria horizontalis	Masandzé	Poaceae	Poales	*Digitaria*	-	+	-
Drymaria cordata (L.)	Namara/ Shirovurovu	Caryophyllaceae	Caryophyllales	*Drymaria*	-	-	+
Dactyloctenium aegyptium (L.)	Nkunu	Poaceae	Poales	*Dactyloctenium*	+	-	-
Eleusine indica (L.)	Makunu	Poaceae	Poales	*Eleusine*	+	-	-
Emilia sonchifolia (L.)		Asteraceae	Atserales	*Emilia*	-	+	-
Chamaesyce hirta (L.)	Idwadzia	Euphorbiaceae	Euphorbiales	*Chamaesyce*	-	-	+
Chamaesyc eprostrata	Msihantsi	Euphorbiaceae	Euphorbiales	*Chamaesyce*	-	-	+
Desmodium incanum		Fabaceae	Fabales	*Desmodium*	+	-	-
Desmanthus virgatus		Fabaceae	Fabales	*Desmanthus*	-	-	+
Digitaria ciliaris (Retz.)		Poaceae	Poales	*Digitaria*	+	-	-
Digitaria horizontalis	Masandzé/Sandzé	Poaceae	Poales	*Digitaria*	-	-	+
Drymaria cordata (L.)	Shirovurovu/ Namara	Caryophyllaceae	Caryophylales	*Drymaria*	-	-	+
Dactyloctenium aegyptium (L.)	Ndawe/ Nkunu	Poaceae	Poales	*Dactyloctenium*	+	-	-
Eleusine indica (L.)	Makunu	Poaceae	Poales	*Eleusine*	+	-	-
Emilia sonchifolia (L.)		Asteraceae	Asterales	*Emilia*	-	-	+
*Euphorbia heterophylla (*L.)		Euphorbiaceae	Malpighiales	*Euphorbia*	+	-	-
Chamaesyce prostrata (Aiton)	Msihantsi	Euphorbiaceae	Euphorbiales	*Chamaesyce*	+	-	-
Conyza sumatrensis (Retz.)		Asteraceae	Asterales	*Conyza*	-	-	+
Galinsoga parviflora		Asteraceae	Asterales	*Galinsoga*	-	-	+
Hibiscus surattensis L.	Kahakaha	Malvaceae	Malvales	*Hibiscus*	-	+	-
Imperata cylindrica (L.)	Mbidambe	Poaceae	Poales	*Imperata*	-	-	+
Ipomoea indica (Burm.)		Convolvulaceae	Solanales	*Ipomoea*	-	+	-
Ipomoea obscura (L.)	Ipamlendje	Convolvulaceae	Solanales	*Ipomoea*	-	+	-
Ipomoea triloba L.	Ipamlendje	Convolvulaceae	Solanales	*Ipomoea*	-	+	-
Ischaemum rugosum	Mbuha	Poaceae	Poales	*Ischaemum*	-	-	+
Kyllinga erecta	Nkunu	Cyperaceae	Cyperales	*Kyllinga*	+	-	-
Pterocypsela indica (L.)		Asteraceae	Asterales	*Pterocypsela*	-	-	+
Lantana camara L.	Bwasera/ Trambamzungu	Verbenaceae	Lamiales	*Lantana*	+	-	-
Mirabilis jalapa L.	Bawalalaaswiri	Nyctaginaceae	Caryophyllales	*Mirabilis*	-	+	-
Mimosa diplotricha	Msiuha/Chibay Amatso	Fabaceae	Fabales	*Mimosa*	-	-	+
Mimosa pudica L.		Fabaceae	Fabales	*Mimosa*	-	-	+

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Momordica charantia L.	Marigozi	Cucurbitaceae	Violales	*Momordica*	-	-	+
Ocimum americanum L.	Kandza/ Sandzani	Lamiaceae	Lamiales	*Ocimum*	+	-	-
Oxalis debilis	Shitsumadzila	Oxalidaceae	Oxalidales	*Oxalis*	-	-	+
*Oxalis corniculata (*L.)	Udzia	Oxalidaceae	Oxalidales	*Oxalis*	-	-	+
*Paederia foetida (*L.)	Itsuzi	Rubiaceae	Rubiales	*Paederia*	-	-	+
Megathyrsus maximus	Umbara	Poaceae	Poales	*Megathyrsus*	-	-	+
Oxalis debilis	Shitsumadzila/Udzia	Oxalidaceae	Oxalidales	*Oxalis*	-	+	-
Panicum umbellatum		Poaceae	Cyperales	*Panicum*	-	-	+
Passiflora foetida L.	Madzanuni	Passifloraceae	Violales	*Passiflora*	-	-	+
Passiflora suberosa L.	Nyambwibwiyi	Passifloraceae	Violales	*Passiflora*	+	-	-
Paspalum conjugatum		Poaceae	Poales	*Paspalum*	-	-	+
Paspalumpaniculatum		Poaceae	Poales	*Paspalum*	-	-	+
Paspalum scrobiculatum L.	Sandze	Poaceae	Poales	*Paspalum*	-	-	+
Pennisetum clandestinum		Poaceae	Cyperales	*Pennisetum*	-	-	+
Pennisetum polystachion (L.)		Poaceae	Cyperales	*Pennisetum*	-	-	+
Ipomoea purpurea (L.)	Ipamlendje	Convolvulaceae	Solanales	*Ipomoea*	-	+	-
*Portulaca oleracea (*L.)	Mbabawure	Portulacaceae	Caryophyllales	*Portulaca*	-	-	+
					-	-	+
Parthenium hysterophorus L.		Asteraceae	Asterales	*Parthenium*	+	-	-
Panicum umbellatum		Poaceae	Cyperales	*Panicum*	-	-	+
Phyllanthus amarus		Euphorbiaceae	Malpighiales	*Phyllanthus*	-	-	+
Phyllanthus tenellus		Euphorbiaceae	Malpighiales	*Phyllanthus*	-	+	-
Melinis repens		Poaceae	Poales	*Melinis*	-	-	+
Rottboellia cochinchinensis	Sandzemadji	Poaceae	Poales	*Rottboellia*	-	-	+
Rubus rosifolius	Frambwazi/ Mbwadigo	Rosaceae	Rosales	*Rubus*	-	-	+
Setaria pumila		Poaceae	Poales	*Setaria*	-	+	-
Sida acuta	Shifungandziya	Malvaceae	Malvales	*Sida*	+	-	-
Sida cordifolia L.	Fundrakole	Malvaceae	Malvales	*Sida*	-	-	+
Sigesbeckia orientalis L.		Asteraceae	Asterales	*Sigesbeckia*	-	-	+
Solanum mauritianum	Mbitsi/Msiwamasera	Solanaceae	Solanales	*Solanum*	+	-	-
*Solanum nigrum (*L.)	Bwa/ Mnavu	Solanaceae	Solanales	*Solanum*	-	-	+
Sorghum arundinaceum		Poaceae	Poales	*Sorghum*	-	-	+
Stachytarpheta jamaicensis (L.)	Kadambimasera	Verbenaceae	Lamiales	*Stachytarpheta*	-	-	+
Stenotaphrum dimidiatum (L.)		Poaceae	Poales	*Stenotaphrum*	+	-	-
Striga asiatica (L.)	Shidadi/Shani	Scrophulariaceae	Lamiales	*Striga*	+	-	-
Teramnus labialis (L.f.)		Fabaceae	Fabale	*Teramnus*	-	-	+
Trichodesma zeylanicum		Boraginaceae	Boraginales	*Trichodesma*	-	-	+
Tridax procumbens (L.)		Asteraceae	Asterales	*Tridax*	-	+	-
*Urena lobata (*L.)	Ndjenimsiru	Malvaceae	Malvales	*Urena*	-	-	+
Vernonia cinerea (L.)	Bogamaziwa	Asteraceae	Asterales	*Vernonia*	-	+	-
102		*29*	23		25	19	56

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Table 2: Species and family richness by island

Parameters	Island 1	Island 2	Island 3
Species and family richness by island	26 species divided into 15 families	20 species divided into 9 families	56 species divided into 20 families
% species	25.49%	19.60%	54.9%
(% families)	(34.09%)	(20.45%)	(45.45%)

Table 3: Global richness in weeds between the studied islands

	GR (island1)* GR (island 2)	GR (island1)* GR (island 3)	GR (island2)* GR (island 3)
% GR	24 (5) = 19 (79.17%)	35 (10) = 25 (71.43%)	29 (5) = 24 (82.76%)
Families	Asteraceae Euphorbiaceae Fabaceae Poaceae Cyperaceae	Amaranthaceae Asteraceae Commelinaceae Convolvulaceae Cyperaceae Euphorbiaceae Fabaceae Malvaceae Oxalidaceae Poaceae	Asteraceae Cyperaceae Euphorbiaceae Fabaceae Poaceae
Coefficient of similarity (Cs)	41.67%	57.14%	34.48%
Jaccard index	5/(24-5) = 0.26	10/(35-10) = 0.4	5/(29-5) = 0.2

Global richness and Jaccard index

The global richness (GR) per island corresponds to the number of different weed families on at least one island. The results are presented in Table 3, illustrating the GR between islands two by two. According to the results, the global richness is highest between Islands 2 and 3, reaching 82.76% (5 families are present on both islands). Between Islands 1 and 2, this richness is 79.17% (5 families are present on both islands), while 71.43% between Islands 1 and 3 (10 families are present on both islands). However, the families common to all three islands are Asteraceae, Cyperaceae, Euphorbiaceae, Fabaceae, and Poaceae, representing a percentage of 11.36% (5/44).

The coefficient of similarity between the flora of the three islands confirms that the three flora are floristically distinct. This coefficient is 41.67% between islands 1 and 2 and 34.48% between islands 2 and 3, both values below 50% (the threshold at which two flora compared are said to be floristically identical or homogeneous). On the other hand, this coefficient is 57.14% between islands 1 and 3.

The distribution of taxa according to the Jaccard index (I) between each pair of islands reveals that this index is 0.4 between islands 1 and 3. This indicates that a significant number of taxa are present in both habitats, suggesting average inter-habitat biodiversity. On the other hand, the index is 0.26 between Islands 1 and 2, which explains the large difference in species between these two habitats. Finally, the index is 0.2 between Islands 2 and 3, underlining that the taxa characteristic of Island 2 differ considerably from those present on Island 3. Jaccard's index is a measure that varies from 0 to 1 and only considers positive associations. When this index increases, it indicates that a significant number of common species are found in both habitats, suggesting low inter-habitat biodiversity due to similar environmental conditions between habitats.

Original richness

Original richness (OR) refers to the number of species present exclusively on one island and absent from others. Indeed, the average original richness between islands 1 and 2 is 29.17%, with 14 original weed families. In contrast, the average original richness between islands 1 and 3 is 19.99%, with a frequency of 14 weed families. However, original richness is highest between islands 2 and 3, reaching 32.75%, with 19 weed families unique to these two islands (Table 4).

The presence of weeds favours, on the one hand, the presence of parasites and pests such as nematodes, weevils, and fungi, and, on the other hand, compete with banana trees. Weeds are, therefore, a major constraint to agricultural production.[9,10] The harmful and beneficial aspects of weeds could be reconciled by recognizing that maintaining weed diversity and preventing the dominance of a few competitive species rely on the same set of ecological processes and management principles.[11] The importance of weed diversity in mitigating yield losses has recently been identified as one of weed science's top five research priorities.[11]

The floristic inventory carried out in banana cultivation in the three Comorian islands made it possible to identify 102 species divided into 29 families. A similar study conducted in two regions, Azaguié Abbè (South) and Éboissué (East), in Ivory Coast by Tano *et al*. [12], identified 161 species distributed in 51 families.[12] In our study, the most represented families are Asteraceae, Cyperaceae, Euphorbiaceae, Fabaceae, and Poaceae. Only the similarity coefficient between islands 1 and 3 exceeds 50%, which results in the homogeneity of families between the two islands. The work of Amank *et al*.[13] and Yapi *et al*.[14] showed that their study sites have a high similarity exceeding 75%. In another study conducted in the departments of Toumodi and Taabo in Côte d'Ivoire, 61 species were identified, divided into 55 genera and 32 botanical families. The Euphorbiaceae and Fabaceae families are the most represented.[15] Moreover, no less than 38 families have been inventoried in the banana plantations of Guadeloupe and Martinique; the Poaceae family was the best represented, with 22 species, or 23%.[16]

Conclusion

The present study was conducted to answer the question of banana weeds and their effect on the production and yield of this flagship crop in the Comoros Islands. In terms of biodiversity, the results show that the three islands are very rich in banana weeds, with 102 weed species

divided into 29 families. The competition for resources created by these weeds, in addition to some environmental, technical, and biological factors, poses a major problem in improving the yield of this nutritious fruit essential to the diet of the Comorian population. There is a need for the Comoros Islands authorities to redouble their efforts in the eradication of these degradation factors mitigating against full bananas yields.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Table 4: Original richness of weeds Between the studied islands

OR (island1)* (island 2)	OR (island 2) * (island1)	OR (island 1) * (island 3)	OR (island 3) * (island 1)	OR (island 2) * (island 3)	OR (island 3) * (island 2)
24 (10)	24(4)	35(5)	35 (9)	29(4)	29(15)
(41.67%)	(16.67%)	(14.28%)	(25.71%)	(13.79%)	(51.72%)
Amaranthaceae Araceae Boraginaceae Brassicaceae Commelinaceae Convolvulaceae Malvaceae Melastomataceae Oxalidaceae Rubiaceae	Apiaceae Cucurbitaceae Nyctaginaceae Sapindaceae	Araceae Boraginaceae Brassicaceae Melastomataceae R ubiaceae	Acanthaceae Caryophyllaceae Lamiaceae Papaveraceae Portulacaceae Rosaceae Scrophulariaceae Solanaceae Verbenaceae	Apiaceae Cucurbitaceae Nyctaginaceae Sapindaceae	Acanthaceae Amaranthaceae Caryophyllaceae Commelinaceae Convolvulaceae Lamiaceae Malvaceae Oxalidaceae Papaveraceae Passifloraceae Portulacaceae Rosaceae Scrophulariaceae Solanaceae Verbenaceae

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