Diversity and Host Plants of Tephritidae From Two Islands of the Comoro Archipelago (Grande-Comore and Moheli).

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DIVERSITY AND HOST PLANTS OF TEPHRITIDAE FROM TWO ISLANDS OF THE COMORO ARCHIPELAGO (GRANDE-COMORE AND MOHELI).

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ABSTRACT

This paper summarizes the different host plants and fruit flies present in two islands (Grande-Comore and Mohéli) of the Comoros Archipelago. Different exotic and wild fruit plants were sampled. Eighty plant species, potential hosts, belonging to thirty-four families were collected and incubated for the emergence of fruit flies from December 2019 to September 2020. Twenty-five plant hosts from ten families comprising cultivated and wild fruits have been identified. Fruit fly infestation rates per kilogram of fruit ($T.Kg^{-1}$) varied from plant to plant. Exotic fruit plants, which accounted for more than half of infested plants, including *Cucumis melo, Cucurbita pepo, Prunus persica, Coffea arabica* and *Capsicum frutescens* had high infestation rates. For wild plants, the highest infestation rates have been observed in some families including *Combretaceae*, *Cucurbitaceae*, *Solanaceae* and *Vitaceae*. The highest infestation rate per kilogram of fruit was observed in a wild plant: *Cyphostemma lageniflorum*. Thirteen new host plants infested by Tephritidae are reported and/or listed for the first time in Comoros. In total, eight species of fruit flies identified. However, the species *Bactrocera dorsalis* Hendel, 1912 (47.5%) and *Dacus bivittatus* (Bigot, 1858) (37.6%) were the most representative of the Tephritidae that emerged.

KEY WORDS: Comoros, Biodiversity, Tephritidae, Host-plants, Infestation rate.

INTRODUCTION

Comoros archipelago is a group of islands in the Indian Ocean, located in the north of the Mozambique Channel, in the south-east of Africa, between the northern Mozambican coast and at the northern tip of Madagascar (11 ° 23'- 13 ° 00′S 43 ° 13'-45 ° 18'E). It includes a group of four main islands: Grande-Comore, Mohéli, Anjouan and Mayotte (Emerick & Duncan, 1982). These four volcanic islands cover from north to south an area of 2,236 km2. However, the emerged lands are distinguished as follows: Grande-Comore (1025 km^2), Mohéli (211 km^2), Anjouan (424 km^2) and Mayotte (374 km^2).

The climate of the Comoros is tropical humid under the influence of the sea. The average temperature varies between 25 ° C and 28 ° C at low altitude (Anllaouddine, 2009). This climate is also characterized by two seasons: from December to April, the weather is hot and rainy (hot and humid season); and between May and November, the weather is cool and dry (dry season) (Adjanohoun *et al.,* 1982 ; Hassani-El-Barwane, 2010). Due to these climatic variations, different types of microclimates develop in the different islands. Due to these climatic parameters, this has allowed the establishment of different fleshy fruits and vegetables, mainly intended for subsistence agriculture, which is a reservoir for fruit flies (De Meyer *et al.,* 2012). However, there is a multitude of other fleshy fruits and vegetables known as wild and not consumed by the population. The latter is an important reservoir for fruit flies because they represent the major part of the fruits and vegetables present in the Comoros Islands.

Although fruit flies are a major problem in Comoros, their range of host plants is poorly understood (Issa, 2017). In all cases, De Meyer *et al.*, (2012) described around ten species of Tephritidae in Comoros. These tephritites were collected by trapping (McPhail trap) containing para-pheromones (Methyl-eugenol, Cuelure, Trimedlure) and/or food additives (Torula)(De Meyer *et al*., 2012). But also, Hassani *and al.*, (2016) studied fruits fly from Comoros. They only identified five species of Tephritidae in 42 plant species sampled in the study.

However, we believe that the methods applied by these researchers are selective and have had many limitations to determine the biodiversity of the host plants of the different species of Tephritidae likely to colonize Comoros. For our part, this study is characterized by the sampling of several ranges of fleshy (or not) fruits and vegetables, wild or cultivated, over large areas, at random periods and in different areas. This study provided a complementary list of host plants and associated Tephritidae found in Comoros (Grande-Comore and Mohéli).

RESULTS

Host plants infestation

A total of 6178 fruit samples were collected in the islands of Grande-Comore and Mohéli from December 2019 to September 2020. They have been identified as 80 species of fruits from 34 families of plant species. However, a few batches of fruit samples were infested with fruit flies. These lots contained 4,669 fruits weighing 69,925 kg in total. Among the fruit species sampled, 25 plant species from 10 families were infested. The main families of infested plants were *Cucurbitaceae*, *Annonaceae*, *Myrtaceae*, *Rutaceae* and *Solanaceae* (**Table 1**). The results also showed that 55 fruit species out of 80 were not infested with tephritids.

Table 1. Plant species sampled during the study in Comoros (Grande-Comore and Moheli) to determine fruit fly host plants (December 2019 to September 2020).

Host families	Scientific name	Common name	Types of plants	Fruit flies	Parasitoids
Aphloiaceae	*Aphloiia theafourmis*	------	Wild	-	-
Anacardiaceae	*Mangifera indica*	Mango	Cultivated	+	-
	Spondias dulcis	Jew plum	Wild	+	-
	Cananga odorata	ilang-ilang	cultivated	-	-
Annonaceae	*Annona squamosa**	Custard apple	Cultivated	+	-
	Annona muricata	Custard-apple	Cultivated	-	-
Apocynaceae	*Thevetia peruviana*	Yellow oleander	Wild	-	-
	Saba comorensis	------	Wild	-	-
Araceae	*Pothos scandens*	------	Wild	-	-
Borraginaceae	*Ebretia sp*	------	Wild	-	-
Bromeliaceae	*Ananas comosus*	Pineapple	Cultivated	-	-
Caricaceae	*Carica papaya*	Papaya	Cultivated	-	-
Combretaceae	*Terminalia catappa*	Tropical almond	Wild	+	+
Cucurbitaceae	*Citrullus lanatus**	Watermelon	Cultivated	+	-
	*Cucumis melo**	Muskmelon	Cultivated	+	-
	Cucumis melo spp.	------	Cultivated	-	-
	*Cucurbita pepo**	Field pumpkin	Cultivated	+	+
	Cucumis sativus	Cucumber	Cultivated	-	+
	Luffa cylindrica	Sponge gourd	Wild/ Cultivated	-	-
	Momordica charantia	Bitter melon	Wild	+	-
	Sechium edule	Chayote	Cultivated	+	+
Cycadaceae	*Cycas thouarsii*	Sago	Cultivated	-	-
Euphorbiaceae	*Jatropha curcas*	Purging nut	Wild/ Cultivated	-	-
Lauraceae	*Persea americana*	Avocado	Cultivated	-	-
Malvaceae	*Abelmoschus esculentus*	Okra	Wild	-	-
Melastomataceae	*Clidemia hirta*	Soapbush	Wild	-	-
	Tristemma mauritianum	------	Wild	-	-
Moraceae	*Artocarpus altilis*	Breadfruit	Cultivated	-	-
	Artocarpus heterophyllus	Jackfruit	Wild	-	-

(*) Host fruits detected and / or listed for the first time in Comoros., **(+)***;* infested *;***(−)** not infested.

Table 1. Continuation…

Host families	Scientific name	Common name	Types of plants	Fruit flies	Parasitoids
Musaceae	*Musa acuminata*	Banana	Cultivated	-	-
Myristicaceae	*Myristica fragrans*	Nutmeg	Cultivated	-	-
Myrtaceae	*Psidium cattleyanum*	Strawberry guava	Wild	+	+
	Psidium guajava	Guava	Wild	+	+
	*Syzygium aromaticum**	Clove / Cengkih	Cultivated	+	-
	Syzygium jambos	Rose-apple	Wild	+	-
	Syzygium malaccense	Malay apple	Cultivated	-	-
Monimiaceae	*Tambourissa comorensis*	------	wild	-	-
Oxalidaceae	*Averrhoa bilimbi*	Cucumber tree	Cultivated	-	-
	Averrhoa carambola	Star fruit	Cultivated	-	-
Passifloraceae	*Passiflora edulis*	Passion fruit	Cultivated	-	-
	Passiflora foetida	Passion flowers	Cultivated	-	-
	Passiflora quadrangularis	Barbadine/Giant granadilla	Cultivated	-	-
Piperaceae	*Piper nigrum*	Black pepper	Cultivated	-	-
Punicaceae	*Punica granatum*	Pomegranate	Wild	-	-
Rosaceae	*Rubis idaeus*	Wild raspberry	Wild	-	-
	Prunus persica	Peach tree	Cultivated	+	-
	Eriobotrya japonica	Japanese plum	Cultivated	-	-
Rubiaceae	*Coffea arabica**	Coffee	Cultivated	+	+
	Morinda citrifolia	Noni	Wild	-	-
Rutaceae	*Citrus aurantifolia**	Key lime	Cultivated	+	-
	*Citrus clemantina**	Clementine	Cultivated	+	+
	Citrus limon	Lemon	Cultivated	-	-
	Citrus maxima	Pomelo/Pummelo	Cultivated	-	-
	Citrus reticulata	Mandarin tree	Cultivated	+	-
	Citrus sinensis	Sweet orange	Cultivated	-	-
Salicaceae	*Flacourtia indica*	Governor's plum	Wild	-	-
Sapindaceae	*Litchi chinensis*	Litchi	Cultivated	-	-
Sapotaceae	*Mimusops comorensis*	------	Wild	-	-
Solanaceae	*Capsicum annum*	Cultivated	Cultivated	-	-
	Solanum americanum	Black nightshade	Wild/ Cultivated	-	--
	Capsicum chinense	Chilli	Cultivated	+	-
	*Capsicum frutescens**	Cayenne pepper	Cultivated	+	-
	*Solanum incanum**	Bitter tomato	Wild	+	-
	Solanum lycopersicum	Tomato	Cultivated	-	-
	Solanum mauritianum	Bugweed	Wild	-	-
	Solanum melongena	Egg plant	Cultivated	-	-
	*Solanum seaforthianum**	Brazilian nightshade	Wild	+	-
	Solanum torvum	Turkey berry	Wild	+	-
	*Solanum tuberosum**	Potato	Cultivated	+	-
	Solanum sp.	------	Wild	-	-
Sterculiaceae	*Theobroma cacao*	Cocoa tree	Cultivated	-	-
Verbenaceae	*Duranta erecta*	Golden dewdrop	Wild	-	-
Vitaceae	*Cyphostemma lageniflorum**	------	Wild	+	-

(*) Host fruits detected and / or listed for the first time in Comoros., **(+)**; infested ;**(−)** not infested.

49 *Diversity of Tephritidae and host plants.*

50 During a 10-month sampling period, 2671 fruit flies emerged from the pupae of the incubated
51 fruits. Eight species from two tribes (Ceratitidini and Dacini) of Tephritidae have been
52 identified. Twenty-five plant species are identified as host plants for Tephritidae. *Bactrocera*
53 *dorsalis* was the species infesting a wide range of host plants (13 plants from 6 families).
54 *Ceratitis capitata* was the second species to infest the most plants (7 plants) of Rubiaceae,
55 Rutaceae and Solanaceae. The species *Neoceratitis cyanescens*, *Trirhithrum nigerrimum*,
56 *Dacus bivittatus* and *Dacus ciliatus* have infested more than one plant species. On the other
57 hand, *Dacus vertebratus* and *Dacus etiennellus* respectively infested only *Citrullus lanatus* and
58 *Cucurbita pepo* (**Table 2**).

59 **Table 2.** List of fruit flies species identified with their localities and inter-altitudes.

Fruit flies species	**Host plants**			
	Family	**Scientific name**	**Locality**	**Inter-altitudes (m)**
Bactrocera dorsalis	Anacardiaceae	*Mangifera indica*	Moroni, Lac-Hantsongoma	35-520
		Spondias dulcis	Inrape	45-55
	Annonaceae	*Annona squamosa*	Bangoi-Kouni	10-50
	Combretaceae	*Terminalia catappa*	Moroni	10-35
	Myrtaceae	*Psidium cattleyanum*	Lac-Hantsogoma, Boboni, Boeni	415-520
		Psidium guajava	Lac-Hantsogoma, Boboni, Chongo-dunda	400-520
		Syzygium aromaticum	Boboni	400-520
		Syzygium jambos	Boboni, Chongo-dunda	350-520
	Rosaceae	*Prunus persica*	Ivembeni	750-840
	Rutaceae	*Citrus aurantifolia*	Wanani, Kangani	240-290
		Citrus clemantina	Mdjoyezi	225-265
		Citrus reticulata	Kangani, Hamavouna	100-250
	Solanaceae	*Solanum incanum*	Bandamadji	300-375
Dacus vertebratus	Cucurbitaceae	*Citrullus lanatus*	Pidjani	5-25
Dacus bivittatus	Cucurbitaceae	*Cucumis melo*	Boboni, Ivembeni	450-800
		Citrullus lanatus	Pidjani	5-25
		Cucurbita pepo	Ivembeni, Bandamadji	465-800
	Solanaceae	*Solanum tuberosum*	Ivembeni	750-840
Dacus ciliatus	Cucurbitaceae	*Cucurbita pepo*	Moroni, Ivembeni, Bandamadji	5-800
		Momordica charantia	Moroni	25-50
		Sechium edule	Ivembeni	750-840
Dacus etiennellus	Cucurbitaceae	*Cucurbita pepo*	Ivembeni	750-800
Ceratitis capitata	Rubiaceae	*Coffea arabica*	Ivembeni	750-840
	Rutaceae	*Citrus clemantina*	Mdjoyezi	240-275
	Solanaceae	*Capsicum chinense*	Ivembeni	800-850
		Capsicum frutescens	Mdjoyezi	225-265
		Solanum incanum	Bandamadji	300-375
		Solanum seaforthianum	Inrape, Douniani	50-265
		Solanum torvum	Moroni	15-50
Neoceratitis cyanescens	Rubiaceae	*Coffea arabica*	Ivembeni	750-840
	Solanaceae	*Solanum incanum*	Bandamadji	300-375
		Solanum tuberosum	Ivembeni	750-840
Trirhithrum nigerrimum	Myrtaceae	*Psidium cattleyanum*	Ivembeni, Mdjoyezi, Dzouadjou, Nioumamilima, kourani	173-735
	Rubiaceae	*Coffea arabica*	Ivembeni	750-840
	Vitaceae	*Cyphostemma lageniflorum*	Iconi, Nvouni	35-400

Abondances relative et fréquences des téphritides

Incubation of 4439 pupae resulted in 2671 fruit flies of different species. The Tephritidae obtained belonged to eight different species with different percentages of occurrence **(Figure 2)**. The species *Bactrocera dorsalis* and *Dacus bivittatus* were largely the most dominant with the respective percentages of 47.5 % and 37.7 %. *Dacus ciliatus* was the third species with 5.6%; followed by *Ceratitis capitata* with 4.2% and *Trirhithrum nigerrimum* with 2.8 %. *Neoceratitis cyanescens* was estimated at 1.6 % of the sample. On the other hand, *Dacus etiennellus* (0.3%) and *Dacus vertebratus* (0.4 %) were the species with low emergence rates.

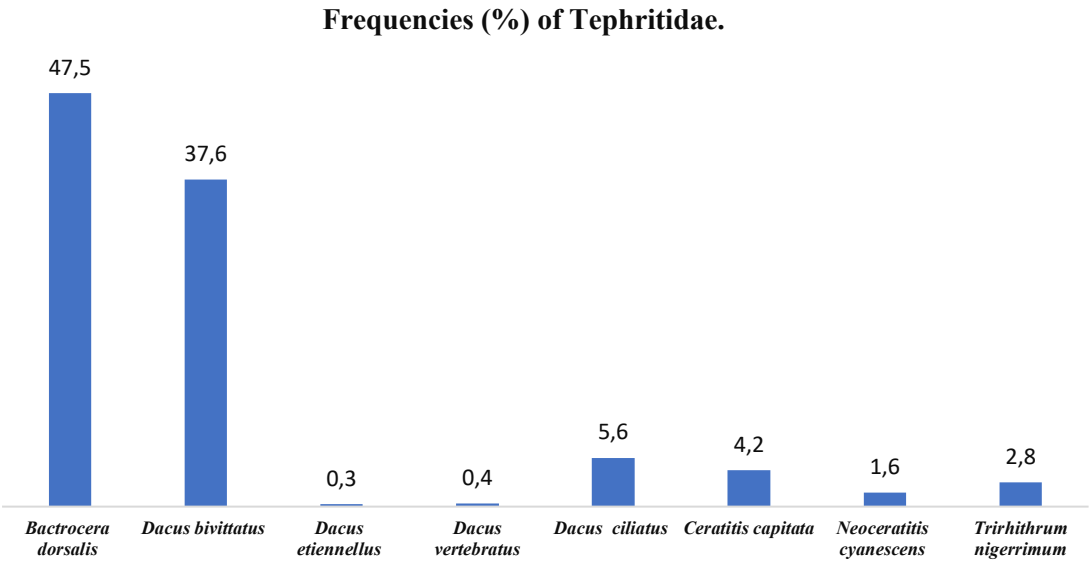

Figure 2. Percentage distribution (%) of Tephritidae.

The abundance of Tephritidae in fruits was influenced by fruit species (*Kruskal-Wallis*, $p<0.001$), Tephritidae species (*Kruskal-Wallis*, $p<0.001$) and the interaction between these two factors. A very significant difference was observed in the level of infestation of fruit flies between the host plants (*Kruskal-Wallis*, $p <0.001$). So there is at least more than one different species of tephritid that has infested the host plants. But also that more than one host plant has been infected with at least two species of fruit flies (**Figure 3**).

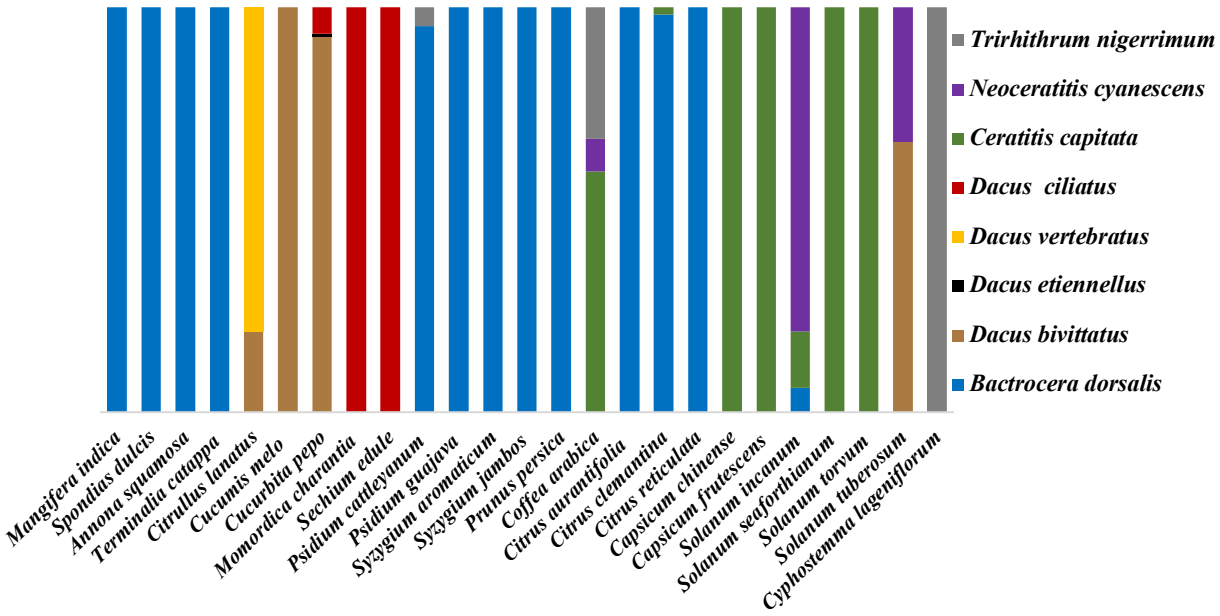

Figure 3. The relative abundances of Tephritidae species in host fruits.

Bactrocera dorsalis infested 13 host plants alone. On the other hand, it shared with *Ceratitis capitata* with the host plant *Citrus clementina* and Trirhithrum nigerrimum with the host plant *Psidium cattleyanum* ; but dominated over 90% infestation. And finally with *Neoceratitis cyanescens* and *Ceratitis capitata* on the host plant *Solanum incanum.*

Ceratitis capitata infested 7 host plants, 4 of which alone were from the Solanaceae family. Another hand, he shared the infestation of host plants including *Coffea arabica* with more than 50 % infestation ; *Citrus clemantina* with less than 5 % and *Solanum incanum* with a little more than 10 % infestation. Only *Dacus bivittatus* infested *Cucumis melo* and shared the infestation respectively of *Cucurbita pepo* and *Solanum tuberosum* with *Dacus ciliatus*, *Dacus etiennellus* and *Neoceratitis cyanescens*.

Dacus ciliatus infected only 3 species of cucurbits. It alone infected *Momordica charantia* and *Sechium edule*. Two species each infected a single host plant. *Dacus etiennellus* infested *Cucurbita pepo*, which it shared in the infestation, and *Dacus vertebratus* which alone infested *Citrullus lanatus*. *Trirhithrum nigerrimum* alone infested *Cyphostemma lageniflorum*. However, it shared the infestation with other species on *Psidium cattleyanum* and *Coffea arabica*.

Fruit fly number per kg of fruit

The number of fruit flies per kg of fruit was not significantly affected by either fruit flies or host plants (*Kruskal-Wallis*, $p < 0.001$). Several species had very high values for the number of flies per kilogram of fruit (**Figure 4**). *Cyphostemma lageniflorum,* infested only by *Trirhithrum nigerrimum*, was the reference species with 1162 flies / Kg of fruit. *Capsicum frutescens* (500 flies / Kg), infested only by *Ceratitis capitata*, was the second species to have a high value. Some host plants infested only by Bactrocera dorsalis had high values for the number of flies per kilogram : *Prunus persica* (430 flies /Kg), *Syzygium jambos* (444 flies /Kg), *Syzygium aromaticum* (250 flies /Kg) and *Terminalia catappa* (288 flies /Kg). *Momordica charantia,* infested by *Dacus ciliatus*, 186 flies / Kg of fruit was observed. *Cucurbita pepo* was the only host plant infested by more species including *Dacus bivittatus*, *Dacus ciliatus* and *Dacus etiennellus* showing a high value of 217 flies / Kg of fruit. In addition, other host plants show moderately high values: *Solanum seaforthianum* (96 flies /Kg), *Solanum incanum* (74 flies /Kg) and *Psidium cattleyanum* (40 flies /Kg). The smallest values were observed almost in cultivated plants including Solanum tuberosum (3 flies / Kg), *Sechium edule* (6 flies / Kg), *Citrus aurantifolia* (6 flies / Kg), *Citrullus lanatus* (13.74 flies / Kg) and *Cucumis melo* (14 flies / Kg).

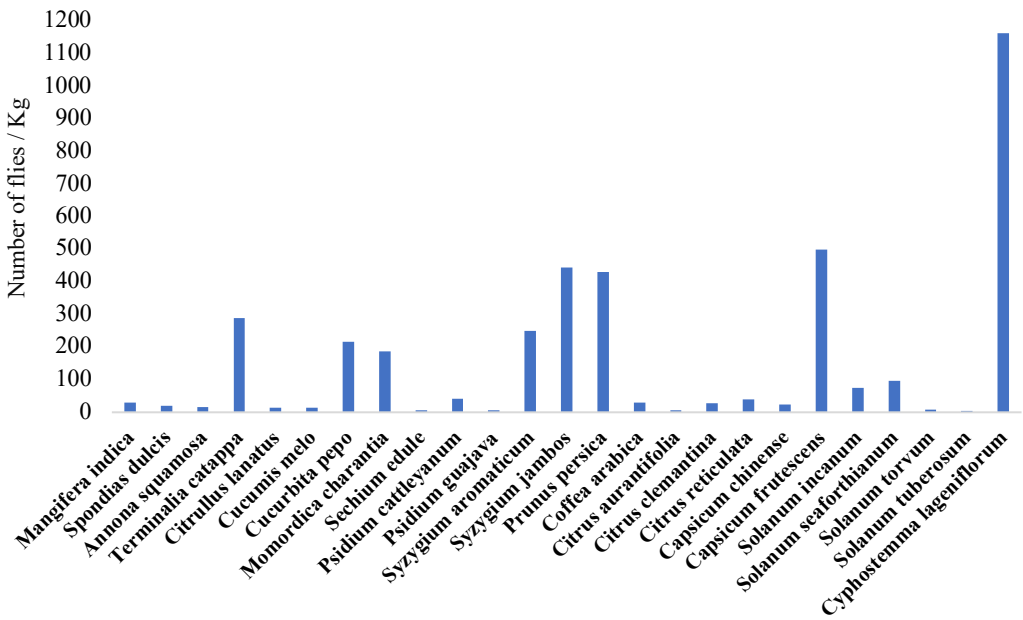

Figure 4. Number of fruit flies per kg of fruit by plant species.

Parasitoids emergence

A very significant difference was observed between the number of parasitoid obtained and the different species of fruit plants. (*Kruskal-Wallis*, $p < 0.001$) (**Table 3**). So there were at least two different species of parasitoids in our samples. The number of parasitoids was not negligible because it represented 3.74 % of the insects that emerged in our samples.

The percentages of samples infested with the parasitoids of *Cucumis sativus* (66.66 %) and *Terminalia catappa* (61.53 %) were the highest. However, small values were observed on two wild plants : *Psidium guajava* (8.8%) and *Psidium cattleyanum* (7.2 %). Indeed, cultivated plants had high percentages compared to wild plants. The wild plants *Terminalia catappa* (35 %) and *Psidium cattleyanum* (22.95 %) had the highest number of parasitoids per kilogram of fruit infestation. On the other hand, the infestation rate observed in the wild plant Psidium guajava remained the lowest. Despite the infestation of host plants by parasitoids, fruit flies emerged in our samples. The only exceptions were *Cucumis sativus* and *Sechium edule*.

Table 3. Presence of parasitoids in the sampled fruits (December 2019-September 2020).

Host plants	Number of P	% Samples	P / Kg of fruits	Species in the same samples
Cucumis sativus	4	66,66	18,18	
Psidium guajava	4	8,8	4,44	*B.dorsalis*
Cucurbita pepo	20	25	14,28	*D.bivittatus*
Citrus clemantina	14	29,62	11,66	*B.dorsalis/ T.nigerrimum*
Psidium cattleyanum	14	7,2	22,95	*B.dorsalis/ T.nigerrimum*
Sechium edule	3	10	5,35	
Terminalia catappa	29	61,53	35	*B.dorsalis*
Coffea arabica	16	32,45	16,5	*B.dorsalis/T.nigerrimum/N.Cyanescens/C.capitata*

P : parasitoids, Kg : kilogramme

The latest literature review of fruit flies in Comoros

Hassani *et al.,* (2016) conducted a similar study of fruit flies from Comoros. Sampling was done on 42 host ranges from 22 families. The results showed that 22 fruit species from 11 families were infested with fruit flies. Six species of fruit flies were detected in the fruits sampled. Unlike this study, the sampling was carried out on three islands of the Comoros. For this study, more species of tephritites were found (**Table 4**).

163 **Table 4** : List of fruit flies species in Comoros Islands in the article of Hassani et al.,[2016a] and this study.

Genus	Species	Hassani et al.,[2016a]	This study
Dacini			
Bactrocera	*dorsalis*	*	*
Dacus	*bivittatus*	*	*
	ciliatus	*	*
	vertebratus		*
	punctatifrons	*	
	etiennellus		*
Ceratitidini			
Ceratitis	*capitata*	*	*
Ceratitis	*malgassa*		
Neoceratitis	*cyanescens*	*	*
Trirhithrum	*nigerrimum*		*

164 * Present

165

166 ## Discussion

167 Among the 80 plant species sampled, 25 species of cultivated and wild plants from 10 families
168 were infested by fruit flies. The relative abundance and seasonal phenology of fruit flies are
169 highly dependent on the availability of host plants. And or the absence of natural enemies that
170 limit the growth of pest populations (Hassani et al., 2016a ; Rwomushana et al., 2008;
171 Mwatawala et al., 2009; Mohamed et al., 2010; Geurts et al., 2012; Badii et al., 2015; Vayssières
172 et al., 2015; Gnanvossou et al., 2017). According to Geurts *et al.* (2012), the diversity of fruit
173 fly species in a biotope depends on the diversity of the host fruit. Previous studies have shown
174 that the dynamics and abundance of fruit fly populations are primarily influenced by host fruit
175 availability and climatic factors (rainfall, temperature, and relative humidity) (Rwomushana et
176 al., 2008; Mwatawala et al., 2009; Mze Hassani et al., 2016a; Gnanvossou et al., 2017).

177 ***Bactrocera dorsalis* Hendel, 1912**

178 *Bactrocera dorsalis*, oriental fruit fly, is a large species complex containing almost 100
179 morphologically similar taxa (Drew and Hancock, 1994). It was first detected on the island of
180 Taiwan in 1912 (De Hardy, 1973). *Bactrocera dorsalis* is home to a number of important pest
181 species such as *B. invadens*, *B. carambolae, B. papayae* and *B. kandiensis* (Drew and Hancock,
182 1994). In Africa, this species was detected in Kenya in 2003 (Lux *et al.*, 2003) and has spread
183 rapidly to several countries in Africa (De Meyer *et al.*, 2010). In West and Central Africa,
184 Bactrocera dorsalis is polyphagous and infests more than 40 plant species (Goergen *et al.,*
185 2011 ; Clarke *et al.,* 2005). In Comoros, it was identified at Grande-Comore in 2005 and
186 Mayotte in 2007 (De Meyer *et al.*, 2012). Indeed, *Bactrocera dorsalis* infested more than half
187 of the samples taken in this study. It colonized almost all the different niches from which the
188 samples were taken. *Bactrocera dorsalis* infested different families of host plants:

Anacardiaceae, Annonaceae, Combretaceae, Myrtaceae, Rosaceae, Rutaceae. Also, it was the type species of our samples with almost 50 % of the flies that emerged. It shared the infestation of some host plants with *Ceratitis capitata*, *Trirhithrum nigerrimum* and weakly with *Dacus bivittatus*. *Bactrocera dorsalis* has been able to acclimatize in different areas at different altitudes. In addition to the thirteen species infested in this study, Hassani *et al.,* (2016a) identified three other host plants of Bactrocera dorsalis in Comoros : *Passiflora edulis, Momordica charantia* and *Annona senegalensis.* So, the species *Bactrocera dorsalis* is associated with sixteen host plants from eight families in Comoros.

***Dacus bivittatus* (*Bigot, 1858*)**

Dacus bivittatus, commonly known as the pumpkin fly, is one of the most common species of the genus Dacus. It has been reported in Africa in 28 countries spread across the continent (White, 2006). It mainly attacks cucurbits such as cucumber and melon (Cucumis melo L.). But it is also reported in hosts other than cucurbits such as tomato (*Lycopersicon esculentum*) (Mwatawala et al., 2016). In the Indian Ocean, in addition to its occurrence in Comoros, Dacus bivittatus reported at Madagascar and Seychelles (Mansell, 2006, White *et al.*, 2000) ; but it's presence in Seychelles not confirmed (De Meyer *et al.*, 2010 ; Hassani et al., 2016a). In our study, *Dacus bivittatus* generally infested Cucurbitaceae family plants (*Cucumis melo, Cucurbita pepo et Citrullus lanatus*). Indeed, this species is capable to infest the Solanaceae group because in this study it infested *Solanum tuberosum*. It is the second species that has emerged the most with nearly 38%. *Dacus bivittatus* acclimatized well in altitudes between 450 m to 800 m. Indeed at these altitudes, the infestation of host plants was very interesting with more than a hundred nymphs appearing after incubation. Neither the weight nor the quantity of the samples played a role. Its presence at low altitude has just been observed in watermelon (*Citrullus lanatus*) at an inter-altitude of 5-25 m with a minimal appearance of a few individuals. The presence of *Dacus bivittatus* is confirmed in Grande-Comore, Anjouan and Mohéli (Hassani et al., 2016a); but it is just associated with the host plant *Cucumis sativus* in Grande-Comore (Hassani et al., 2016b). However in our study *Dacus bivittatus* did not infest Cucumis sativus; but it infested *Cucurbita pepo*, *Citrullus lanatus* and *Cucumis melo*. However, there was just an appearance of parasitoids in Cucumis sativus without any fruit flies or nymphs.

Dacus ciliatus Loew, 1862

Commonly referred to as the "Ethiopian fruit fly" or "little pumpkin fly"; *Dacus ciliatus* is a widespread African species. Generally, this species attacks a wide variety of Cucurbitaceae (Mwatawala *et al.,* 2006). It seems to thrive in drier areas like the Sahel, Namibia and the Karoo. *Dacus ciliatus* has been observed in several regions of the world including the Near and Middle East and South Asia (De Meyer *et al.,* 2012). In the Indian Ocean, it's identified in Mauritius and Reunion (White, 2006) and at Madagascar (White, 2006 ; Mansell, 2006 ; White, 1992). In the Comoros Archipelago, adults were seen in a cucumber patch in M'Réréni, Mayotte. (Quilici, 1996 ; De Meyer *et al.,* 2012). In the study of Hassani *et al.,* (2016b), *D. ciliatus* is detected in Anjouan in traps containing torula yeast. The author hypothesizes that the presence of *D. ciliatus* in Anjouan can probably be explained by the presence near the study sites of many hosts of cucurbits such as chayote (*Sechium edule*), cucumber (*Cucumus sativus*) and pumpkin (*Cucurbita maxima*). However in Grande-Comore it is obtained in traps containing Cuelure (De Meyer *et al.,* 2012) ; and isolated from *Momordica charantia* (Hassani et al.,2016a). In our study, *Dacus ciliatus* represented 5.6% of the adults that emerged in the total samples. This species only infested plants of the Cucurbitaceae family : *Cucurbita pepo, Sechium edule* et *Momordica charantia*. *Dacus ciliatus* shared the infestation of a single host plant, *Cucurbita pepo*, with *Dacus bivittatus* and *Dacus etiennellus.*

Dacus vertebratus Bezzi, 1908

Commonly known as the melon fly or the jointed pumpkin fly, *Dacus vertebratus* is a known pest of cucurbits, particularly watermelon (*Citrullus lanatus*) and several *Cucumis spp.* (White, 2006). This species is widespread and present in most Afro-tropical countries, the Arabian Peninsula and Madagascar (De Meyer et al., 2012). In Comoros Archipelago, Dacus vertebratus was first recorded in Mayotte by Bordat and Arvanitakis (2004). De Meyer *et al.,* (2012) identified a few species in Grande-Comore and Anjouan. But these specimens were captured in traps containing Cuelure and Torula. However, these studies have not associated with well-defined host plants. In our study, Dacus vertebratus infested only Citrullus lanatus. He shared the infestation in this host plant with Dacus bivittatus with a low infestation rate.

***Dacus etiennellus* Munro, 1984**

Close relative of *D. bivittatus*, *Dacus etiennellus* is an endemic species of the Comoros Archipelago (De Meyer at al., 2012). It was identified for the first time in 1974 in Mayotte or

Grande Comore (White, 2006). It is closely related to *D. demmerezi* (Bezzi) (present in Madagascar, Mauritius and Reunion), but differs in the shape of the coastal strip of the wing. (De Meyer *at al.,* 2012). In these studies, no plant host was associated with *D. etiennellus*. However, De Meyer *et al.,* (2012) identified some specimens captured in a Cuelure trap. In this study, *Dacus etiennellus* infested Cucurbita pepo at inter-altitudes of 750-800 m. This infestation is shared with *D. bivittatus*.

***Ceratitis capitata* (*Wiedemann, 1824*)**

The Mediterranean fruit fly is the most common fruit fly in the world. Some researchers characterize it as the most harmful fruit fly (Mwatawala *et al.,* 2006 ; De Meyer *at al.,* 2012). Probably from eastern or southern Africa (De Meyer *et al.,* 2002), it has spread throughout the world and colonizing nearly 400 host plants thus acquiring the term polyphages (Clarke *et al.,* 2005 ; Liquido *et al.,* 1998 ; De Meyer *et al.,* 2002b). In Africa, Ceratitis capitata is extremely polyphagous with more than a one hundred different host plants from about thirty families (De Meyer *et al.,* 2002b ; De Meyer *et al.,* 2012). In the Ocean Indian Islands, Ceratitis capitata was probably introduced because it has been observed in several islands (De Meyer 2000; De Meyer *et al.,* 2008; White et al. 2000). In Comoros, male specimens are captured in traps containing trimedlure ; and females and males in traps containing torula (De Meyer *et al.,* 2012). After *B. dorsalis*, *Ceratitis capitata* remains the second species that infested several host plants at the same time (*Solanum torvum, Solanum seaforthianum, Solanum incanum, Capsicum frutescens, Capsicum chinense, Citrus clemantina* and *Coffea arabica*). It infested plants of the Solanaceae, Rutaceae and Rubiaceae families at different altitudes (15 m to 850 m). *Ceratitis capitata* shared the infestation of some host plants with *Neoceratitis cyanescens, Trirhithrum nigerrimum* and *Bactrocera dorsalis.*

***Neoceratitis cyanescens* (Bezzi, 1923)**

The genus *Neoceratitis* Hendel is a predominantly afrotropical group (Yun *et al.,* 2017). *Neoceratitis cyanescens* is considered endemic to Madagascar (De Meyer *et al.,* 2012). Their populations have the potential to grow rapidly in several different habitats where both wild and cultivated fruiting hosts are present throughout the year (Brévault *et al.,* 2008). The main host plants of *Neoceratitis cyanescens* are plants of the Solanaceae family and rarely *Passiflora edulis* (Hassani *et al.,* 2016a ; Brévault *et al.,* 2008). *Neoceratits cyanescens* is a serious pest of tomato on the islands of the Indian Ocean (Madagascar and Réunion) (Brévault et al., 2008).

282 In Comoros, this species was observed for the first time in a tomato plot in Mayotte (Quilici,
283 1996). In the other islands, the tomato fly was reported by Kassim *et al.*, (2000) ; but the report
284 lacked more details. Hassani *et al.,* (2016a) reported that the main wild fruits infested with *N.*
285 *cyanescens* were *Solanum mauritianum* and *Solanum torvum*, while the commercial fruits were
286 chili (*Capsicum chinense*) and tomato (*Solanum lycopersicum*). In our study, *N. cyanescens*
287 infested *Solanum incanum* and *Solanum tuberosum* (Solanaceae) et *Coffea arabica* a plant of
288 the Rubiaceae family. *N. cyanescens* shared the infestation in *C. arabica* with *T. nigerrimum*
289 and *C. capitata* ; in *S. incanum* with *B. dorsalis* and *C. capitata* and in *S. tuberosum* with *D.*
290 *bivittatus*.

291 ***Trirhithrum nigerrimum* (Bezzi, 1913)**

292 *Trirhithrum* Bezzi, 1918, is an Afrotropical genus of 40 species belonging to the Ceratitidini
293 tribe (subfamily Dacinae) (White *et al.,* 2003). In the Indian Ocean islands exist some endemic
294 species, but none of these has been recorded in Comoros. Only Trirhithrum nigerrimum,
295 widespread throughout Africa, has been identified in Comoros (De Meyer *et al.,* 2012). Indeed,
296 it has been identified in the islands of the Comoros archipelago except in Grande-Comore.
297 Characterized as the pest of coffee (Rubiaceae) (White et Elson -Harris, 1994), *T. nigerrimum*
298 attacks a variety of host plants (polyphagous) (White *et al.,* 2003). In this study, *T. nigerrimum*
299 showed a strong infestation preference for *Cyphostemma lageniflorum* (Vitaceae). For this
300 plant, the infestation per kilogram of fruit far exceeded other host plants of Tephritidae. It
301 infested *Coffea arabica* (Rubiaceae), which is shared with *C. capitata* and *N. cyanescens*. And
302 finally, *T. nigerrimum* infested *Psidium cattleyanum* (Myrtaceae) with *B. dorsalis.*

303 Finally, eight species of fruit flies have identified from twenty-five infested host plants in this
304 study. In the report by Hassani *et al.,* (2016a), several host plants different from ours were
305 reported : *Annona senegalensis*, *Passiflora edulis*, *Citrus sinensis*, *Cucumis sativus* and
306 *Solanum lycopersicum*. In the same report, *Dacus punctatifrons* was identified in some
307 cucurbits. Thus, the number of Tephritidae in Comoros amounts to nine (9) fruit flies associated
308 with thirty (30) host plants.

309 **Parasitoïdes**

310 Hassani *et al.,* (2016a) identified four species of tephritid parasitoids in Comoros : *Fopius*
311 *arisanus*, *Diachasmimorpha fullawayi*, *Psyttalia insignipennis* et *Psyttalia phaeostigma*. They
312 belonged to the *Braconidae* family and the *Opiinae* subfamily. In this study, an identification

of the different species of parasitoids was not made. However, a very significant difference was observed between parasitoids and infested host plants (**Kruskal-Wallis**, $p < 0.001$). So, there were at least two different species of parasitoids that emerged in our samples. In total, around one hundred parasitoids have emerged in eight host plants from five plant families (*Cucurbitaceae, Rutaceae, Myrtaceae, Rubiaceae* et *Combretaceae*). Unlike the study by Hassani *et al.,* (2016 a) of 2013-2016, we observed a significant emergence in the number of parasitoids. Several plants have been infested with both parasitoids and fruit flies. Only *Cucumis sativus* and *Sechium edule* were the exceptions. It should be noted that not all sample lots of *Cucumis sativus* were infested by any fruit flies (Tephritidae).

Materials and Methods

Study sites

This research work was carried out in Comoros (Grande-Comore and Mohéli). For ten months (December 2019 to September 2020), we made field trips on both sides of the two islands. Grande-Comore remains the largest island, with different microclimates, with an area of 1025 km^2. It is approximately 40 km^2 from Mohéli, which is its neighbouring island. Mohéli island is the smallest of the four islands, with an area of 211 km^2. Despite its small size, this island contains significant microclimates. Indeed, although these islands are of the same nature and close to each other, very diverse and varied climatic ecosystems exist there. The localities in which the samples were taken are indicated by dots followed by the name of the locality in ***Figure 1.*** The variation in the altitude at which the samples were taken was significant in the range of 5 m to 877 m.

Figure 1. Sampling sites in both islands.

Sampling

Sampling was carried out on two islands of the Comoros archipelago. The fruits were collected in 30 locality in the islands between December 2019 and September 2020. The fruits were collected at random according to their availability on each of the sites. Priority has been given particularly to sites with a large diversity of fruits to maximize the diversity of the plant species sampled. The sampling areas included coastal forests, mid-latitude forests, areas of intense agricultural activity, mangroves, cultivated fields, backyard gardens and roadsides. Ripe and sometimes unripe fruits were harvested by hand and sometimes with a knife. At each location, approximate latitude, longitude and altitude were taken using a global positioning system (GPS). These GPS data were recorded at the site of each collection or the nearest opening, if the fruits are collected in a dense area. Collections do not represent an equal sampling effort as some fruits were much easier to find and harvest than others at a given time and place. The fruit collections were placed in individual plastic bags and closed directly to avoid contamination (Copeland *et al.,* 2002). Also, photos are taken regularly before each harvest of the fruit or

vegetable and of the entire plant for the identification or verification of plant species at the Comoros herbarium (University of Comoros). The harvested fruits were transported to a breeding unit at the National Research Institute for Agriculture, Fisheries and the Environment (INRAPE-Comoros).

Incubation of fruit samples

The fruit samples were weighed and placed in transparent boxes containing previously sand (one or more fruits of the same species per box) of dimensions 12x7x9 cm, 11x9.5x8 cm and/or 7x7x4 cm, depending on the size of the fruits (Hassani, 2016a). The lids were perforated and covered with muslin to allow ventilation. After a week to ten days of incubation of the fruit, pupae appear. These are collected by filtering the sand through a sieve. All pupae collected from an individual fruit are placed in a transparent box with a perforated lid covered with muslin. After the emergence of adults, the fruit flies were placed in Eppendorf (1.5ml) containing 95% alcohol before being identified (sexes, groups).

Fruit fly identification

Fruit flies that emerged from pupae from laboratory rearing were grouped into morphotypes. This first sorting was based on the key to identifying Tephritidae of electronic economic importance. (key_to_African_Tephritids_v1) (Virgilio *et al*., 2014). Confirmation of these species identifications was carried out at the Entomology section of the Royal Museum for Central Africa (Tervuren, Belgium).

Statistical analysis

Differences between the levels of infestation by host plants, fruit flies and emerged parasitoids were analyzed using Kruskal-Wallis tests with $p < 0.001$ in R v. 4.0.3 under the "*Rcmdr*" library. The tests are considered significant at the 5% level. This test is a nonparametric alternative to first-order *ANOVA* (intergroup).

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