Ecological relationships between *Ceratitis* spp. (Diptera: Tephritidae) and other native fruit tree pests in southern Mozambique

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Ecological relationships between *Ceratitis* spp. (Diptera: Tephritidae) and other native fruit tree pests in southern Mozambique.

Abstract — Introduction. Insect pest identification and understanding of insect pest ecological relationships constitute a basic step for any control measure needed. Some native fruit trees occur naturally in southern Mozambique and the edible fruits are sought after by local communities. Our study aimed at assessing the activity of native fruit tree insect pests during the year and their ecological relationships, providing, for the first time, a faunistic analysis of insect species affecting fruit trees in the region of Maputo, Mozambique. **Materials and methods**. Entomological surveys were carried out between June 2002 and December 2003 in the Districts of Manhiça, Marracuene, Namaacha and Matutuíne (southern Mozambique). Quadrangular 900-m^2 plots were established in fields where *Annona senegalensis, Garcinia livingstonei* and *Vangueria infausta* native fruit trees naturally occurred. The number of individual insect pests per fruit, tree and plot was recorded to estimate ecological fauna measurements: the affinity index, association index and simultaneous constancy. **Results and conclusion**. A total of 1648 insect specimens, belonging to eight insect species, were found while conducting the ecological observations on *Annona senegalensis* Pers (Annonaceae), *Garcinia livingstonei* T. Anders (Clusiaceae) and *Vangueria infausta* Burch (Rubiaceae). Two groups of pests were observed: defoliators and insects attacking the fruits, which represented the majority. Affinity between insect species was observed, with the relationship between *Ceratitis capitata* Wiedemann and one unidentified species of the Cosmopterigidae family reaching the highest values. *C. capitata* was also found to have the highest association index with *Spatulipalpia monstrosa* Balinsky (Lepidoptera: Pyralidae), as well as *Carpophilus* sp. (Coleoptera: Nitidulidae) and *Araecerus* sp. (Coleoptera: Curculionidae). *C. capitata* and *Araecerus* sp. had the highest simultaneous occurrence in different locations. Cluster analysis also indicated that *Ceratitis capitata* and *Carpophilus* sp. had the highest similarity percentage in all samples.

Mozambique / fruit trees / indigenous species / animal population / leaf-eating insects / fruit-damaging insects / population ecology / host plants

Relations *in situ* entre *Ceratitis* spp. (Diptera : Tephritidae) et d'autres parasites d'arbres fruitiers indigènes du sud du Mozambique.

Résumé — Introduction. L'identification d'insectes parasites et la compréhension des relations *in situ* entre ces ravageurs constituent une étape primordiale pour leur contrôle. Certains arbres fruitiers indigènes se développent naturellement au sud du Mozambique et leurs fruits comestibles sont recherchés par les populations locales. Notre étude a cherché à évaluer l'activité des ravageurs de ces arbres fruitiers au cours de l'année et à analyser leurs relations, fournissant, pour la première fois, une analyse faunistique des espèces d'insectes affectant les arbres fruitiers dans la région de Maputo au Mozambique. **Matériel et méthodes**. Des prospections entomologiques ont été effectuées entre juin 2002 et décembre 2003 dans les zones de Manhiça, Marracuene, Namaacha et Matutuíne (sud du Mozambique). Des parcelles rectangulaires de 900 m^2 ont été établies dans des aires où les arbres fruitiers indigènes *Annona senegalensis, Garcinia livingstonei et Vangueria infausta* produisaient naturellement. Le nombre d'insectes parasites par fruit, arbre et parcelle de terrain a été enregistré pour estimer des paramètres faunistiques : index d'affinité, index d'association, et constance de présence simultanée. **Résultats et conclusion**. Un total de 1 648 spécimens, appartenant à huit espèces d'insecte, a été trouvé à l'issue des observations écologiques faites sur *Annona senegalensis* Pers. (Annonaceae), *Garcinia livingstonei* T. Anders (Clusiaceae) et V*angueria infausta* Burch. (Rubiaceae). Deux groupes de parasites ont été observés : des insectes défoliateurs et, en majorité, des ravageurs de fruits. Une affinité a été mise en évidence entre les espèces d'insectes grâce à une relation étroite entre *Ceratitis capitata* Wiedemann et une espèce non identifiée appartenant à la famille Cosmopterigidae. *C. capitata* s'est également révélée avoir l'index d'association le plus élevé avec *Spatulipalpia monstrosa* Balinsky (Lepidoptera: Pyralidae), il en a été de même pour *Carpophilus* sp. (Coleoptera: Nitidulidae) et *Araecerus* sp. (Coleoptera: Curculionidae). *C. capitata* et *Araecerus* sp. ont eu l'occurrence simultanée la plus élevée en plusieurs lieux. L'analyse des groupes a également indiqué que *Ceratitis capitata* et *Carpophilus* sp. avaient le plus fort pourcentage de similitude dans tous les prélèvements.

Mozambique / arbre fruitier / espèce indigène / population animale / insecte phyllophage / déprédateur des fruits / écologie des populations / plante hôte

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Received 27 October 2005
Accepted 18 July 2006

Fruits, 2007, vol. 62, p. 35–44

DOI: 10.1051/fruits:2006047
www.edpsciences.org/fruits

***RESUMEN ESPAÑOL**, p. 44*

1. Introduction

Native fruit trees provide fruits used for consumption and income increase for rural householders representing, therefore, a potential for small business. However, heavy losses in forest production and tree fruit collection have been reported, most of them caused by pests and diseases. Some flies such as *Ceratitis rosa* Karsch (= *Pterandrus rosa* Karsch) are regarded as major pests, attacking many tropical and wild hosts, citrus, peach (*Prunus persica* (L.) Batsch (Rosaceae), native fruit trees and other fruits of commercial importance, causing heavy losses each year [1]. Fruit flies cause damage during larval feeding. According to Hill [2], secondary disease infections usually follow the insect attack. The fruit pulp becomes soft and gets rotten. Fruits fall prematurely. Many maggots can be found on the fruit pulp. The insect is able to breed in vigorous and greener fruits and has several wild hosts not yet well known [2]. The majority of the pests are not yet known, and neither is their pest status. Established interdependencies between populations of insect pests and other insect species, including natural enemies, can determine the abundance of insect pest populations, allowing or not that a certain species expresses itself as a pest. Insect pest identification and understanding of insect pest ecological relationships constitute a basic step for any control measure where it is needed. In their studies, Garcia *et al.* [3] observed that literature regarding faunistic analyses on fruit flies was rare. For Southern Africa such information is even scarcer. The same authors also noted that several works provided lists without an account of the ecological relationships among the various species.

Some native fruit trees such as *Annona senegalensis, Vangueria infausta* and *Garcinia livingstonei* occur naturally in southern Mozambique and the edible fruits are sought after by local communities [4]. Our study aimed at assessing the activity of native fruit tree insect pests during the year and their ecological relationships, providing, for the first time, a faunistic analysis of insect species affecting fruit trees in the region of Maputo, southern Mozambique.

2. Materials and methods

2.1. Study area

Samples were carried out in the districts of Namaacha (26° 13' S, 32° 07' E), Matutuíne (26° 23' S, 32° 23' E), Marracuene (25° 44' S, 32° 40' E) and Manhiça (25° 26' S, 32° 42' E) of southern Mozambique from June 2002 to December 2003.

According to Santos [5], in these districts, the climate is tropical, with temperatures reaching the average maximum of 30.5 °C in January, the hottest month in the wet season, and average minimum of 10.3 °C in July, during the cool and dry season. Soils tend to be shallow and not suitable for agriculture in some sites [6–10], indicating that the region is adequate for fruticulture with some limitations due to the cyclic occurrence of drought and pests. The host plants included in the surveys were *Annona senegalensis*, *Vangueria infausta* and *Garcinia livingstonei*.

Due to the effect of air temperature on fruit fly larval development [11], meteorological data regarding the monthly average minimum, maximum and mean temperature, as well as total rainfall, were recorded for every sampling month and plot in the Manhiça location.

2.2. Sampling procedure

At least three sampling plots sized 900 m^2 were marked and observed per location, totalizing 56 sampling plots for collecting fruit infestation data. Due to the nature of the damage on the trees, pests were separated into two groups, namely, the defoliators and the fruit pests. Insect infestation of the fruit pests was estimated by relating infested fruits to total number of fruits borne per tree per plot. Insect pest activity for both pest groups was assessed by using estimates of insect density observed for each tree's fruits and leaves, respectively, for the fruit pests and defoliators within the sampling plots.

For insect density data, and insect ecological measurements, samples were taken

in a total of 27 plots. Assessment of defoliator larval density was done by direct visual counting on every fruit tree within the sampling plot. In order to estimate the density of the fruit pests including fruit flies, the infested fruits were collected and taken to the laboratory for posterior counting of insect specimens at the larval stage inside the fruit. Only the infested fruits were collected from every single tree. The number of collected fruits varied according to infestation levels. All larval instars were the only development stages considered in this study. Samples were taken once per plot to avoid dependence of data, as recommended by Underwood [12].

Absolute population density (D) was estimated using the equation recommended by Carvalho [12]: $D = (A \times N) / (a \times n)$, where A is the total sampling quadrat area; N, the number of insects in all quadrats; a, the individual quadrat area, and n, the number of quadrats.

2.3. Measurements of insect ecology

The pest ecological measurements were investigated using techniques recommended by Carvalho [13], Lara [14] and Garcia *et al.* [3]. The observations used for these analyses were those taken from September 2002 to May 2003, the insects' peak activity months.

Specimens were sent to the London History Museum, UK, for species identification.

2.3.1. Species frequency

The species frequency measurement was determined as the percentage of the number of individuals per species in relation to the total number of individuals found per sample unit, as recommended by Garcia *et al.* [3]. According to the values found per species, they were classified as less frequent, frequent and very frequent [3]. Cluster analysis of insect species frequency on sampling units was performed to assess the degree of similarity of insect species occurrence in the sampling sites.

2.3.2. Affinity index

The affinity index (I_{AB}) [14] measures the frequency with which two insect species simultaneously occur in one community: $I_{AB} = 2j / (n_A + n_B)$, where n_A is the number of occurrences of species A; n_B, the number of occurrences of species B, and j, the number of simultaneous occurrences of species A and B.

2.3.3. Association index

The association index (I) estimates the association level between two insect species based on the total number of individuals of the two species occurring together in the surveys [14]: $I = [j/ (A + B)] - 0.5$, where A is the number of individuals of species A collected in every survey; B, the number of individuals of species B collected in every survey, and j, the number of individuals of species A and B collected in the surveys in which they occurred simultaneously.

This index may vary from –1, which means no association between the two species, to +1, where there is complete association between the two insect species.

2.3.4. Simultaneous constancy

The measure of "constancy" for a species was used to describe the percentage at which a given insect species was present in the samples, as indicated by Lara [14].

2.4. Data analyses

In order to assess the variance homogeneity of the insect counts before submitting data to the analysis of variance, data on attack levels per sampling month were transformed using either logarithmic or square root transformations.

An analysis of variance using the "General Linear Model" was performed on the variables regarding insect infestation levels per sampling season and tree species. Statistical analyses were done using the software "Minitab for Windows", release 12.1.

Duncan tests at the 5% significance level were performed for comparisons between means, as described by Gomes [15] and Leeuwen [16].

The meteorological data of every sampling month used as the explanatory variable were regressed by multiple regressions

Table I.
Numbers of inspected trees per studied tree species, number of fruits and infested fruits in 56 sampling plots observed during the period from June 2002 to December 2003 in southern Mozambique.

Tree species	Number of trees	Number of fruits	Number of infested fruits
Annona senegalensis	1775	7487	1688
Garcinia livingstonei	255	4741	2584
Vangueria infausta	809	16156	32

against the fruit infestation percentage for the respective sampling month.

3. Results and discussion

During the period of study, a total of 28 384 fruits was inspected in 2839 trees in a total of 56 sampling plots with naturally occurring fruit tree species for infestation estimates (*table I*). The insect specimens, observed on the native fruit trees, *Annona senegalensis*, *Vangueria infausta* and *Garcinia livingstonei*, belong to eight species of eight genera, and three orders represented by seven families. A total of 1648 insect specimens from 27 sampling plots were used in the faunistic analyses (*table II*). Among these specimens, 1345 pests, therefore more than 80%, belong to the group causing damage to the fruits, which is likely to be direct since the tree species observed are mostly used for fruit collection, consumption and commercialization.

Six fruit pests were observed in this study (*table II*). The fruit fly *Ceratitis capitata* was found attacking the fruits of *A. senegalensis* and *G. livingstonei* and shared *A. senegalensis* with three other insect pests and *G. livingstonei* with a lepidopterous fruit borer of the family Cosmopterigidae, being

Table II.
Presence (×) of fruit pests and defoliators on the respective host fruit tree in 27 sampling plots sampled for ecological studies in southern Mozambique.

Insect species	*Annona senegalensis*		*Garcinia livingstonei*	*Vangueria infausta*		Number of insect specimens found in ecological studies	Location		
	Fruits[1]	Leaves[2]	Fruits[1]	Fruits[1]	Leaves[2]		Marracuene	Manhiça	Matutuíne
Araecerus[3] sp.	–	×	–	×	–	565	272	293	0
Carpophilus[4] sp.	×	×	–	×	–	358	157	201	0
Ceratitis capitata[5]	×	–	×	–	–	165	87	78	0
Cosmopterigidae (Lepidoptera)[6]	–	–	×	–	–	158	91	67	0
Endaeus floralis[7]	×	–	–	–	–	51	0	0	50
Graphium (Arisbe) *morania* (Angas)[8]	–	×	–	–	–	7	0	0	7
Petovia dichroaria dichroaria[9]	–	–	–	–	×	296	0	0	296
Spatulipalpia monstrosa[10]	×	–	–	–	–	48	0	48	0

[1] Attacked by fruit pests; [2] attacked by defoliators.

[3] *Araecerus* sp. (Coleoptera: Curculionidae); [4] *Carpophilus* sp. (Coleoptera: Nitidulidae); [5] *Ceratitis capitata* Wiedemann (Diptera: Tephritidae); [6] unidentified species; [7] *Endaeus floralis* Marshall (Coleoptera: Curculionidae); [8] *Graphium* (Arisbe) *morania* (Angas) (Lepidoptera: Papilionidae); [9] *Petovia dichroaria dichroaria* H.-S. (Lepidoptera: Geometridae);[10] *Spatulipalpia monstrosa* Balinsky (Lepidoptera: Pyralidae).

present in all samples. Two coleopterous species, namely, *Araecerus* sp. and *Carpophilus* sp., shared the same host plants, *A. senegalensis* and *V. infausta*. In terms of insect species frequency, among the insect fruit pests, the most frequent species were *Ceratitis capitata*, *Araecerus* sp. and *Carpophilus* sp., while the least frequent species were *Endaeus floralis* and *Spatulipalpia monstrosa* (*table II*).

These findings differ from those reported by Garcia *et al*. [3], where *C. capitata* was classified as accidental, probably due to the different environmental conditions such as host plants and different insect species sharing the habitat, resulting in different behavior and different ecological relationships.

Two insect species, both belonging to the order Lepidoptera, were defoliators, namely, *Petovia dichroaria dichroaria* (Lepidoptera: Geometridae), a pest of *V. infausta* and *Graphium* (Arisbe) *morania* (Angas) (Lepidoptera: Papilionidae), a pest of *A. senegalensis*.

3.1. *Ceratitis capitata*

The whole life-cycle of *C. capitata* took less than 2 months, with eggs hatching in 3 days on average, larvae taking 7 days to pupate and adult emergence taking place 10 days after pupation. An adult's life-cycle lasted around 2 weeks. This insect pest appeared relatively free of natural enemies at the sampling sites. Only 2% of *C. capitata* larvae were parasitized by a hymenopterous parasitoid, to be identified. Although small, this proportion is within the parasitation range observed by Garcia and Corseuil [17] for fruit flies in Brazil.

A species of *Ceratitis* other than *C. capitata* was observed feeding on *A. senegalensis* fruits. It was only collected in one sampling period. The immature stages of all fruit pests, except for *C. capitata* that pupated in the soil, were spent inside the fruit until adult emergence.

Ceratitis cosyra (Walker) (Diptera: Tephritidae) was only found in species of the genus *Citrus* and so was not included in this study focusing on native fruit trees occurring naturally.

3.2. Other fruit pests

Araecerus sp. and *Carpophilus* sp. attacked both *A. senegalensis* and *V. infausta* fruits. *Endaeus floralis* Marshall (Coleoptera: Curculionidae) and *Spatulipalpia monstrosa* were specific to *A. senegalensis*, whereas an unidentified species of the Cosmopterigidae family (Lepidoptera) attacked *G. livingstonei* fruits.

3.3. Insect pest activity during the year

The analysis of variance to assess insect activity by evaluating fruit infestation levels per sampling month did not show evidence of differences between months during the wet season, with $F_{(2,37)} = 5.13$; $P > 0.05$. The Duncan test did not detect differences between infestation level means per month for *Garcinia livingstonei*, *Vangueria infausta* and *Annona senegalensis* (*table III*).

Working with *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera: Tephritidae), Garcia *et al*. [18] found population fluctuations during the months of the year in Brazil. These authors noted that fruit fly peak activity was associated with fructification periods, which, in this study, occurred at different moments. This fact may have contributed to the similar activity by the insect pests during the year (*table III*). During the course of the year, the insects, apparently, found different alternative plant hosts, not being host-specific. This fact may indicate the suitability of undertaking further ecological studies during the season since the insect activity remained equally high during the different sampling periods. The regression analysis to assess the influence of meteorological factors on insect activity did not show evidence of an association between monthly average temperature and rainfall with infestation levels by insect activity. This relationship is expressed by the equation: $y = 76 - (405 \times$ monthly average temperature in °C) + (197 × monthly average maximum temperature in °C) + (209 × monthly average minimum temperature in °C) – (0.018 × monthly total precipitation in mm). Standard deviation was 7.329; R^2, 86.9%; $F_{(4,2)}$, 10.99; P, 0.085.

Table III.
Mean number of infested fruits per sample unit for native fruit tree species observed in southern Mozambique. Means are not significantly different according to the Duncan test.

Infestation month and year		*Annona senegalensis*[1]	*Garcinia livingstonei*[1]	*Vangueria infausta*[1]
2002	September	–	1.4 ± 0.2	1.4 ± 0.1
	October	1.5 ± 0.2	0.2 ± 0.2	1.5 ± 0.2
	November	0.9 ± 0.1	1.0 ± 0.2	–
	December	–	–	–
2003	January	–	–	–
	February	0.6 ± 0.1	–	1.6 ± 0.1
	March	0.9 ± 0.1	–	0.7 ± 0.1
	April	–	–	0.1 ± 0.1
	May	–	–	–
	June	–	–	–
Coefficient of variation (%)		41.72	52.15	63.49

[1] Mean number ± standard error. – No fruit infestation.

Garcia and Corseuil [11], studying fruit flies' response to meteorological factors, found a significantly positive effect of the climatic conditions on *C. capitata* insect larval development, with the mean and maximum temperatures having the strongest influence. The contrasting results in this study may also be explained by a narrow range of figures concerning meteorological data observed during the period of study (*table IV*), confirming reports by Reddy [19] for the region of study.

Garcinia livingstonei was the tree species with the highest infestation levels on the fruits, which reached more than 50% in September and October, corresponding to the months of fruit maturation in the study area (*figure 1*). October tended to be the month of highest insect activity for *Annona senegalensis* and *Vangueria infausta* (*table III*).

3.4. Affinity index

The affinity index, which shows a positive dependence between the numbers of individuals of two different insect species, revealed that there is the highest affinity between the species of the Cosmopterigidae family and *Ceratitis capitata* in Marracuene, and between *Araecerus* sp. and *Carpophilus* sp. in Manhiça (*table V*). In both locations, the affinity observed between the species of the Cosmopterigidae family and *C. capitata* was more than 0.90. In Manhiça, there is also high affinity between *Spatulipalpia monstrosa* and *Cosmopterigidae*, and between *S. monstrosa* and *C. capitata* (*table V*). These findings provided in our study may indicate

Table IV.
Monthly average of meteorological data registered in the Manhiça location (southern Mozambique) during the months of a native fruit tree survey to study the fruit infestations.

Sampling month		Temperature (°C)	Maximum temperature (°C)	Minimum Temperature (°C)	Rainfall (mm)	Average infestation levels (%)
2002	September	20.2	28.1	12.3	66.3	52.77
	October	21.9	29.5	14.3	98.0	39.27
	November	21.6	29.2	14.0	111.0	14.92
	December	23.5	29.9	17.1	68.6	–
2003	January	–	33.2	18.6	60.9	–
	February	26.8	33.7	20.0	122.1	14.52
	March	25.3	31.3	19.2	125.5	2.95
	April	23.2	29.8	16.5	48.2	2.67
	May	20.1	27.2	13.0	65.1	0.00
	June	17.6	23.9	11.4	383.4	–

an adaptation of *C. capitata* populations to develop and grow with other insect species, thus reaching significant attack levels, with potential negative consequences to fruit production in the study area.

In Matutuíne, almost no affinity occurred between insect pest species (*table V*).

3.5. Association index

The association index, which estimates the association level between two insect species, showed that, apparently, according to the classification recommended by Lara [14], the association was almost total between *Araecerus* sp. and *Carpophilus* sp., and *C. capitata* and the unidentified species of the Cosmopterigidae family (*table VI*).

3.6. Simultaneous constancy

The simultaneous constancy index, used for assessing the simultaneous occurrence of a given species in two communities in order to observe potential similarities between these two communities, was only estimated for the communities where the same species occurred, namely, Manhiça and Marracuene. The most predominant insect species found in the study locations were *Araecerus* sp., *Carpophilus* sp. and *Ceratitis capitata*, simultaneously occurring, respectively, in 96.3%, 87.7% and 92.3% of the samples in Manhiça and Marracuene. A fourth insect pest was found to occur in both locations, the unidentified species of the Cosmopterigidae family, which showed a simultaneous

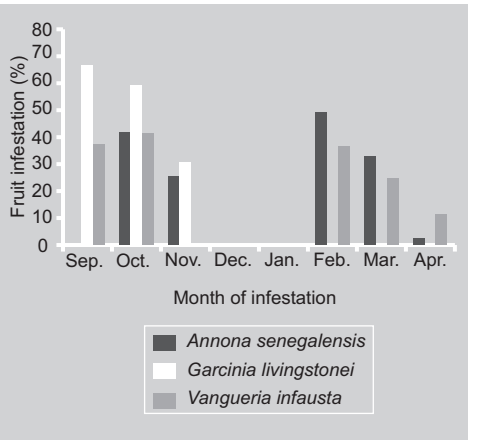

Figure 1.
Percentage of fruits infested in native fruit tree species observed in relation to the sampling months (hot and wet season from October to March; dry and cool season from April to September [5]) in southern Mozambique.

Table V.
Affinity index (I_{AB}) between insect species observed in fruits of native fruit trees in three locations of southern Mozambique. $I_{AB} = 2j / (n_A + n_B)$, with n_A, number of species A occurrences; n_B, number of species B occurrences, and j, number of species A and B simultaneous occurrences.

Insect species considered		Manhiça	Marracuene	Matutuíne
Araecerus sp.	*Carpophilus* sp.	0.81	0.74	–
	Ceratitis capitata	0.42	0.5	–
	Cosmopterigidae	0.37	0.48	–
	Spatulipalpia monstrosa	0.28	–	–
Carpophilus sp.	*Ceratitis capitata*	0.56	0.73	–
	Cosmopterigidae	0.5	0.71	–
	Spatulipalpia monstrosa	0.39	–	–
Cosmopterigidae	*Ceratitis capitata*	0.92	0.98	–
Endaeus floralis	*Graphium morania*	–	–	0.24
	Petovia dichroaria dichroaria	–	–	0.34
Graphium morania	*Petovia dichroaria dichroaria*	–	–	0.05
Spatulipalpia monstrosa	*Ceratitis capitata*	0.76	–	–
	Cosmopterigidae	0.83	–	–

– No occurrence of the two pest species.

Table VI.
Association index (I) between insect species occurring in Marracuene and Manhiça (southern Mozambique) in fruits of natural fruit trees. I = [j / (A + B)] – 0.5, with A, number of species A individuals collected in every survey; B, number of species B individuals collected in every survey, and j, number of species A and B individuals collected in the surveys in which they occurred simultaneously.

Insect species		Association index
Araecerus sp.	*Carpophilus* sp.	0.9
	Ceratitis capitata	– 0.3
	Cosmopterigidae	– 0.3
Carpophilus sp.	*Ceratitis capitata*	– 0.3
	Cosmopterigidae	– 0.2
Cosmopterigidae	*Ceratitis capitata*	0.9

constancy of 87.0%, confirming an association between the studied insect species.

Cluster analysis based on the correlation between insect species composition and frequency per sample indicated that *Ceratitis capitata* and *Carpophilus* sp. had occurrence similarity higher than 85% in the region, while, for these two insect species and the unidentified species of the Cosmopterigidae family, the similarity percentage was above 82%, at a 0.95 similarity level (*figure 2*), confirming the results of the association index and affinity index described above.

Detailed studies on the identified pest biology are recommended, as well as more in-depth studies to understand the interactions between the pests and their host plants and the insect pests and their natural enemies, particularly the unknown factor causing mortality of *Ceratitis capitata* pupae.

4. Conclusions

In total, eight insect species were observed attacking native fruit trees in the Maputo region, apart from *Ceratitis cosyra* on citrus trees. The species *C. capitata* had a high affinity index with *Spatulipalpia monstrosa* and an unidentified species of the Cosmopterigidae family, and the highest association index with the species of the Cosmopterigidae family. The two species, *C. capitata* and *Araecerus* sp., were simultaneously constant in the study locations. There was similarity in occurrence of *Ceratitis capitata*, *Carpophilus* sp. and the species of the Cosmopterigidae family.

Less than 2% of the *Ceratis capitata* population were attacked by a hymenopterous parasitoid at the larval stage, although the still unknown mortality key factor appears to affect the insect pupae.

There is no evidence of differences in pest activity between the sampling months.

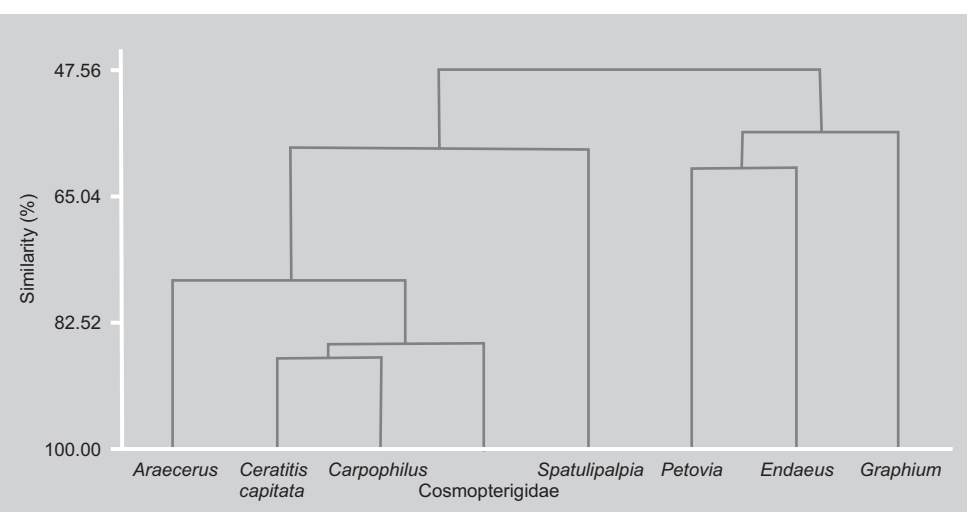

Figure 2.
Similarity of eight insect species' occurrence found in native fruit tree species sampled in the Manhiça, Marracuene and Matutuíne locations in southern Mozambique.

Acknowledgements

We thank the International Foundation for Science and the Department of Forestry, Eduardo Mondlane University, for providing financial and logistic support for the realization of this study. Our thanks are also extended to the reviewers of the manuscript for their valuable criticisms for improving it.

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Relaciones *in situ* entre *Ceratitis* spp. (Diptera: Tephritidae) y otros parásitos de árboles frutales indígenas del sur de Mozambique.

Resume — Introducción. La identificación de parásitos y la comprensión de las relaciones *in situ* entre estas plagas constituye una etapa primordial de todo control. Ciertos árboles frutales indígenas se desarrollan naturalmente en el sur de Mozambique y sus frutos comestibles son demandados por las poblaciones locales. Nuestro estudio pretendió evaluar la actividad de las plagas de estos árboles frutales a lo largo del año; así como analizar sus relaciones, aportando de este modo, por primera vez, un análisis faunístico de las especies de insectos que afectan a los árboles frutales en la región de Maputo, en Mozambique. **Material y métodos**. Se llevaron a cabo prospecciones entomológicas entre junio de 2002 y diciembre de 2003 en las zonas de Manhiça, Marracuene, Namaacha y Matutuíne (sur de Mozambique). Se establecieron parcelas de 900 m^2 en terrenos donde los árboles frutales indígenas *Annona senegalensis, Garcinia livingstonei* y *Vangueria infausta* producían de modo natural. El número de insectos parásitos por fruto, árbol y parcela de terreno se registró con el fin de estimar parámetros faunísticos: índice de afinidad, índice de asociación, y constancia de presencia simultánea. **Resultados y conclusión**. Un total de 1648 especímenes pertenecientes a ocho especies se hallaron gracias a observaciones ecológicas realizadas en *Annona senegalensis* Pers. (Annonaceae) *Garcinia livingstonei* T. Anders (Clusiaceae) y *Vangueria infausta* Burch. (Rubiaceae). Se observaron dos grupos de parásitos: insectos desfoliadores, y plagas de frutos que fueron mayoritarias. Se puso de manifiesto una evidencia entre las especies de insectos, gracias a una estrecha relación entre *Ceratitis capitata* Wiedemann y una especie no identificada, perteneciente a la familia Cosmopterigidae. *C. capitata* resultó asimismo tener el índice de asociación más alto junto con *Spatulipalpia monstrosa* Balinsky (Lepidoptera : Pyradilae) y lo mismo ocurrió con *Carpophilus* sp., Coleoptera : Nitidulidae) y *Araecereus* sp. (Coleoptera : Curculionidae). *C. capitata* y *Araecerus* sp. tuvieron el caso simultáneo más elevado en muchos lugares. El análisis de los grupos indicó también que *capitata* y *Carpophilus* sp. poseían el porcentaje más alto de similitud en todas las extracciones.

Mozambique / árboles frutales / especies indígenas / población animal / insectos depredadores de las hojas / insectos depredadores de los frutos / ecología de las poblaciones / plantas huéspedes