Original article

Seasonal occurrence of fruit flies in strawberry guava (*Psidium cattleianum* Sabine) in Réunion Island: host phenology and fruit infestation

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Seasonal occurrence of fruit flies in strawberry guava (*Psidium cattleianum* Sabine) in Réunion Island: host phenology and fruit infestation.

Abstract — Introduction. Strawberry guava (*Psidium cattleianum*), widespread in Réunion Island, is a major host plant for different fruit fly species. Relations between fruit fly population dynamics, host phenology and fruit infestation were studied. **Materials and methods**. Seasonal occurrence of fruit flies was determined by male trap captures from 1992 to 1994 in three natural areas invaded by *P. cattleianum* located at elevations of 100 m, 480 m and 720 m on the wet windward coast of the island. Strawberry guava fruit infestation was monitored during harvest. **Results**. The major fruit fly species captured at all sites was the Natal fruit fly, *Ceratitis rosa* Karsch. The Mediterranean fruit fly *C. capitata* (Wiedemann) and the Mascarenes fruit fly *C. catoirii* (Guérin-Mèneville) were occasionally trapped at elevations of 100 m and 480 m. Strawberry guava is a host for these three species from sea level to an elevation of 500 m. Only *C. rosa* infested fruit at higher elevations. This species was by far the most important in infested fruit. *C. rosa* populations were low during most of the year, but increased when strawberry guava fruit reached maturity. *C. rosa* abundance differed significantly between the sites, but without clear relation with elevation. **Discussion and conclusion**. These results provide new information on the population dynamics of the Natal fruit fly. Our findings are useful for determining spray schedules against this economic pest in commercial strawberry guava orchards. © Éditions scientifiques et médicales Elsevier SAS

Réunion / *Psidium cattleianum* / phenology / *Ceratitis* / population dynamics / traps / identification / host parasite relations

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Fluctuations saisonnières des populations de mouches des fruits sur goyavier-fraise (*Psidium cattleianum* Sabine) à l'île de la Réunion : phénologie de l'hôte et infestation des fruits.

Résumé — Introduction. Le goyavier-fraise, très répandu sur l'île de la Réunion, est une plante hôte majeure de différentes espèces de mouches des fruits. Les relations entre la dynamique de population des mouches des fruits, la phénologie de la plante hôte et les dégâts sur fruits ont été étudiés. **Matériel et méthodes**. L'évolution saisonnière de l'abondance des mouches des fruits a été étudiée de 1992 à 1994 par piégeage sexuel dans trois zones naturellement envahies par *P. cattleianum* situées à 100 m, 480 m et 720 m d'altitude sur la côte humide de l'île. Les dégâts sur fruits ont été suivis durant les récoltes. **Résultats**. La principale espèce de mouche des fruits capturée sur l'ensemble des sites a été la mouche du Natal, *Ceratitis rosa* Karsch. La mouche méditerranéenne des fruits, *C. capitata* (Wiedemann), et la mouche des fruits des Mascareignes, *C. catoirii* (Guérin-Mèneville), ont été occasionnellement capturées à 100 m et à 480 m d'altitude. Le goyavier-fraise s'avère être une plante hôte pour ces trois espèces du niveau de la mer jusqu'à 500 m d'altitude, avec une nette dominance de *C. rosa*. Au-delà de 500 m, seule cette espèce a été rencontrée dans les fruits piqués. Les populations de *C. rosa* ont été faibles durant toute l'année et ont augmenté au moment de la récolte du goyavier-fraise. L'abondance de *C. rosa* a varié significativement entre les sites, mais sans relation claire avec l'altitude. **Discussion et conclusion**. Ces résultats apportent des informations nouvelles sur la dynamique des populations de la mouche du Natal en relation avec l'une de ses principales plantes hôtes. Ils sont utiles pour définir des programmes de traitements phytosanitaires contre les mouches des fruits dans les vergers commerciaux de goyaviers-fraises. © Éditions scientifiques et médicales Elsevier SAS

Réunion / *Psidium cattleianum* / phénologie / *Ceratitis* / dynamique des populations / piège / identification / relation hôte parasite

1. introduction

Réunion Island is a French overseas department located in the southwest Indian Ocean (21° 06' S, 55° 32' E). It is mountainous and under the influence of a tropical climate with high rainfall (3 000–5 000 mm) on the windward coast, and dry weather (700–1 200 mm) on the leeward coast.

Strawberry guava (*Psidium cattleianum* Sabine) was introduced to the island in about 1818 and it rapidly colonized the native wet forest and disturbed areas from the sea level to an elevation of 1 300 m. It is present on 12 000 ha and forms very dense stands in certain places (*figure 1*) [1, 2]. The red fruit is appreciated by the inhabitants as fresh or processed fruit. Gathering activities in the feral stands supply processing industries and locally give some economic importance to this fruit. To face a growing market, *P. cattleianum* is now tested as a diversification crop in wet areas of the island [3]. The main complaint about the strawberry guava is the high percentage of fruit infested by fruit fly larvae, particularly at low and medium elevation (< 1 000 m). In many tropical areas, strawberry guava is an important host for different fruit fly species: *Ceratitis capitata* (Wiedemann) [4, 5], *Bactrocera dorsalis* (Hendel) and to a lesser extent *B. cucurbitae* (Coquillett) [6] in Hawaii, *Anastrepha suspensa* (Loew) in Florida [7, 8].

In Réunion Island, the Natal fruit fly, *Ceratitis rosa* Karsch, introduced in about 1950, is predominant over a large range of ecological conditions. It is found from sea level to an elevation of 1 500 m. It is a highly polyphagous species and has been recorded infesting 31 host plants on the island [9]. Many cultivated fruit species are among its common hosts: mango (*Mangifera indica* L.), peach (*Prunus persica* (L.) Batsch), guava (*Psidium guajava* L.), loquat (*Eriobotrya japonica* (Thunb.) Lindl.), bullock-heart

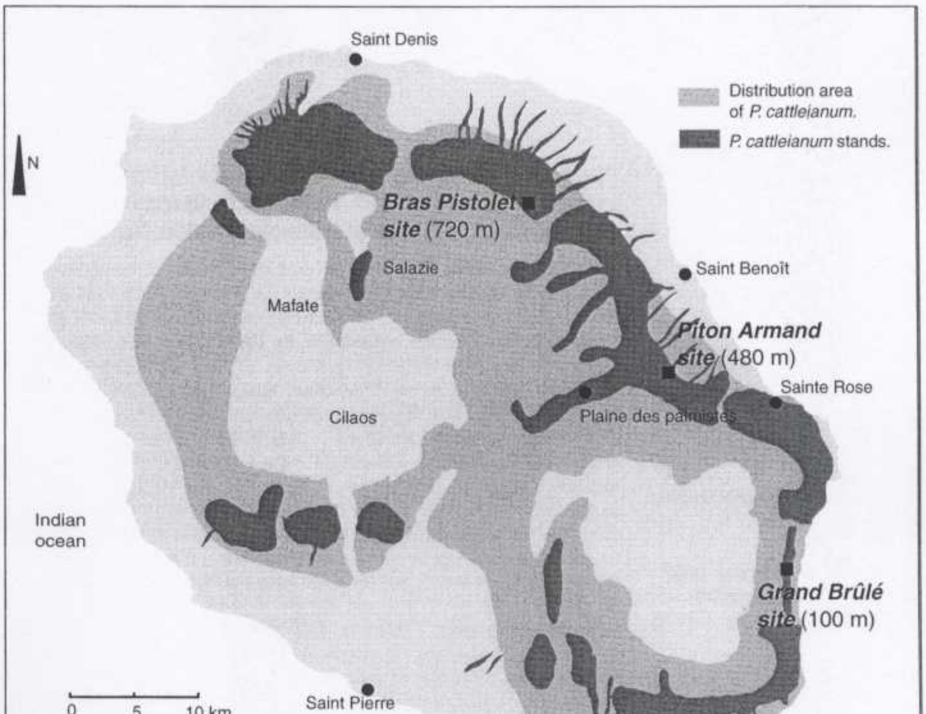

Figure 1.
Réunion Island map showing the distribution area and the main stands of *Psidium cattleianum*, and the location of the study sites: Grand-Brûlé, Piton Armand and Bras Pistolet (adapted from [2]).

(*Annona reticulata* L.), *Citrus* sp. [9]. However, a few cultivated or uncultivated exotic plants are also recorded as major host plants, such as strawberry guava (*P. cattleianum*), rose apple (*Syzygium jambos* (L.) Aston), bug weed (*Solanum auriculatum* Ait.), and coffee (*Coffea arabica* L.) [9]. Large feral populations of *P. cattleianum* are considered as one of the major Natal fruit fly reservoirs in Réunion Island [9, 10].

The Mediterranean fruit fly, *C. capitata*, and a related endemic species, the Mascarenes fruit fly *Ceratitis catoirii* (Guérin-Mèneville), are also present on the island. These two species seem to suffer from a strong interspecific competition with *C. rosa*. The usually large host range of *C. capitata* is limited to some 14 species in the island. Its major host plants include cultivated fruit [tangerine (*Citrus nobilis* Lour.), orange (*Citrus sinensis* (L.) Osbeck), red chili (*Capsicum frutescens* L.)] as well as uncultivated fruit [coffee (*Coffea arabica* L.) Surinam cherry (*Eugenia uniflora* L.), tropical almond (*Terminalia catappa* L.), blacknight shade (*Solanum nigrum* L.), and *Ehretia* sp.] [9]. Until now, this species has not been reported to infest *P. cattleianum* on the island. The medfly is found in areas of low to medium elevation and its populations reach their highest levels in the dry areas of the lowlands in the west and south parts of the island. *C. catôirii* has only five host plants known in the island: *T. catappa* and *E. uniflora* are the main ones. *P. cattleianum*, *P. guajava* and *M. indica* are also rarely infested. It is mostly found at low to medium elevations, in the wet areas of the east and south-east parts of the island [9, 10].

The objective of this study was to determine the relationships between fruit fly population dynamics, strawberry guava phenology and fruit infestation by the different tephritid species in order to evaluate the role of feral strawberry guava stands as fruit fly reservoirs. Moreover, fruit flies are the main pests of *P. cattleianum*, a promising fruit tree for agricultural diversification in humid areas, and the results of this study would be useful to the development of fruit protection strategies in the orchards.

2. materials and methods

2.1. study sites and strawberry guava phenology

The study was conducted over a period of 2 years in three stands of feral strawberry guava located at elevations of 100 m (Grand-Brûlé), 480 m (Piton Armand) and 720 m (Bras Pistolet) on the windward wet coast of Réunion Island (*figure 1*). The lower site is a forest dominated by *Casuarina equisetifolia* L. on recent lava flows where strawberry guava forms dense stands. There is no agricultural nor residential activity in this location. The sites at medium and high elevations are at the frontier between the forest and fallows resulting from surrender of sugar cane cultivation. Strawberry guava trees are abundant in these disturbed areas. Annual rainfalls are 4 000–5 000 mm at 100 m asl (above sea level) and 6 500–7 500 mm at 480 m and 720 m asl.

Strawberry guava phenology was determined by counting the main phenological stages (shoot emergence, flowering, fruit growth and fruiting period) on five marked branches from five trees (i.e. 25 branches on each site), every 10 d. Moreover, the beginning and the end of the fruiting period were recorded by a general survey of strawberry guava trees.

The daily thermic gradient between the automatic meteorological stations of *Météo France* at Saint Benoît (40 m asl) and Plaine des Palmistes (1 025 m asl) has been used to estimate mean daily air temperatures on the Piton Armand and Bras Pistolet sites. On the Grand-Brûlé site, mean daily temperatures from the close automatic meteorological station of *Météo France* at Sainte Rose (180 m asl) have been used.

2.2. fruit fly trapping system

On each site, three traps were set on strawberry guava branches at eye level. The trapping system was an 'Addis' trap [10], dry Nadel type trap, baited with a 'Magnet' (Agrisense) trimedlure dispenser and a dimethyl-dichloro-vinyl-phosphate (DDVP) strip. Trimedlure is an effective sexual attractant for the males of the three *Ceratitis* species present on the island [9]. Every 10 d, traps were checked to count the flies trapped. The trimedlure dispenser and the DDVP strip were renewed monthly.

2.3. fruit infestation

Fruit infestation has been studied by on-field survey when fruit were available and by fruit dissection in the laboratory. Fly emergence from large fruit samples completed these data.

The fruit infestation was checked at each visit during the fruit growth period. When the first damage appeared, the percentage of infested fruit was recorded every 10 d on a 100 fruit sample collected randomly.

At 480 m and 720 m asl, samples of 300 fruit were randomly collected at the beginning and in the middle of the 1993 fruiting period to determine the phenological stages of fruit at which it may be punctured by the female fly. Fruit were ranked according to a six colour scale (light green, green–yellow, yellow, yellow–red, red, dark red) corresponding to increasing maturity levels. Light green and green–yellow fruit were immature. Fruit were then individually examined and classified as infested or non-infested. For each infested fruit, the presence or absence of eggs and maggots was recorded by dissection. Twenty infested fruit were then individually isolated to examine fruit fly emergence from single infested fruit using the method described below.

Larger samples of ripe fruit were also randomly collected on the sites during the 1992 and 1993 fruiting periods and taken to the laboratory to record fruit fly emergence from the whole sample. Fruit were counted and placed on a metal screen above a plastic box containing 2 cm of sand kept slightly humid. Boxes were held for 3 weeks until total fruit decomposition. Sand was sifted weekly and pupae were placed in small ventilated plastic boxes containing a piece of sponge soaked with a nipagene + benzoate solution to maintain a humid atmosphere and avoid rot. These boxes were placed at 25 °C. Fruit flies emerged within 10 d. Pupae and emerged flies from different species were then counted.

2.4. statistical analysis

On each site, fruit fly abundance was determined by the number of flies caught per trap and per day. For each year, maximum trap captures of *C. rosa* on the three sites were subjected to analysis of variance after a $\log(x + 1)$ transformation. Untransformed means are presented in the results section. If a significant difference was found, a Tukey's multiple comparison test was used to perform pairwise comparisons between means at the $p = 0.05$ level [11].

Degree of association between trap captures of *C. rosa* and fruit infestation was based on correlation coefficients. Kendall's tau correlation coefficients were calculated separately for each site and each year [11].

To test if the proportion of infested immature fruit (number of infested immature fruit / total number of immature fruit of the sample) is affected by the sampling date on a site, a Fisher's exact test [11] has been used on the data of the 300 fruit samples collected at 480 m and 720 m asl at the beginning and in the middle of the 1993 fruiting period.

3. results

3.1. strawberry guava phenology and fruit fly captures

On the three study sites, strawberry guava generally had one fruiting cycle per year, and new shoots bearing flower buds appeared in mid-October and the beginning of November. Then the temperature, in negative relation with elevation, induced different rates of fruit development which contributed to extend the fruiting period from March in the lowlands to June in the highlands. In the lowlands, harvest lasted 1–1.5 months and, in the highlands, 2–3 months. Nevertheless, because of the strawberry guava presence on a wide range

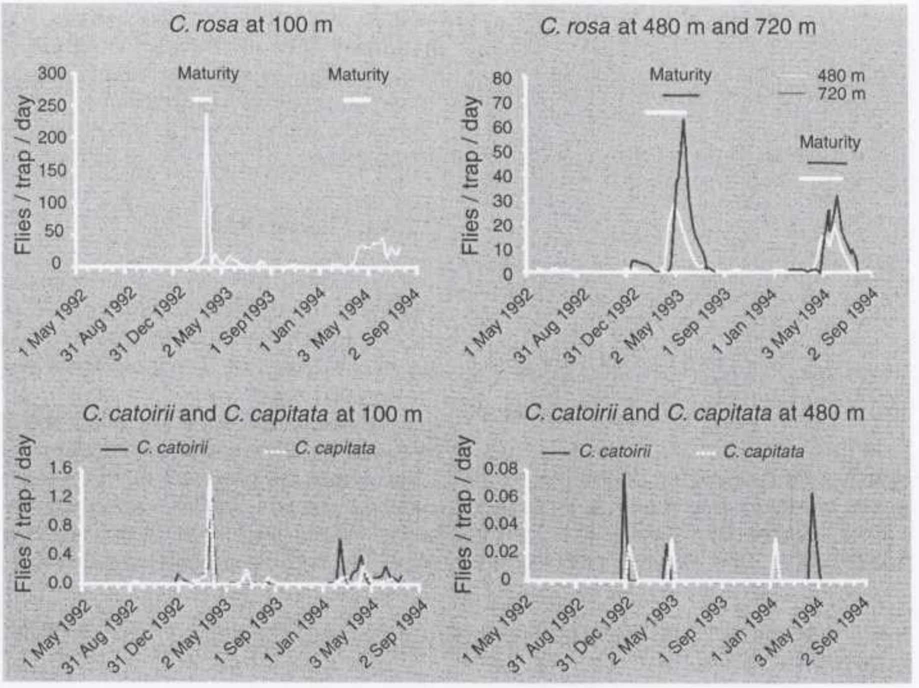

Figure 2.
Seasonal occurrence of *Ceratitis rosa, C. catoirii* and *C. capitata* as indicated by the mean number of flies caught per trap and per day, on three strawberry guava feral stands located at different elevations.

of elevations, the over-all fruiting period lasted several months. A resting period followed until the following October. At low elevation, a second scarce fruiting cycle during which fruit reached maturity in July occurred after the fruit set of the main cycle.

In each location, Natal fruit fly populations remained at a very low level of about 0.28 flies / trap / day throughout the year, except during the strawberry guava fruiting period when they rapidly increased (*figure 2*). Temporary increases in fruit fly populations outside the strawberry guava fruiting period were probably due to other unidentified host plants. At low elevation, the highest captures took place at the end of the fruiting period (in 1993) or just after (in 1994). Captures remained at a significant level until August. At the elevations of 480 m and 720 m, the highest captures coincided with the mature fruit production peak in the middle of the fruiting period. Captures then decreased as the harvest ended. At 720 m, a capture buildup occurred in February during both years, probably due to another host plant which has not been identified.

Mean daily air temperature decreased between the beginning and the end of the fruiting period. Mean temperatures [mini; maxi] in the course of the fruiting period at 100 m, 480 m and 720 m asl were, respectively, 23.7 °C [20.5; 27.0], 20.9 °C [17.6; 23.8] and 17.9 °C [12.2; 20.9] in 1993, and 25.3 °C [22.4; 27.4], 20.6 °C [15.3; 23.7] and 17.9 °C [14.4; 22.4] in 1994.

The maximum *C. rosa* abundance differed significantly between the sites during the 1993 fruiting period ($n = 3$; $F_{2,6} = 10.8$; $p = 0.01$) and during the 1994 fruiting period ($n = 3$; $F_{2,6} = 6.36$; $p = 0.03$) (*table I*). It was always higher at 100 m asl, lower at 480 m asl and intermediate at 720 m asl.

At 100 m asl, the maximum *C. rosa* abundance was significantly lower during the 1994 fruiting period than during the 1993 one ($n = 3$; $F_{1,4} = 8.94$; $p = 0.04$). At 480 m and 720 m asl, it was also lower during the 1994 fruiting period than during the 1993 one, but the differences were not significant ($n = 3$; $F_{1,4} = 2.47$; $p = 0.19$, and $n = 3$; $F_{1,4} = 6.16$; $p = 0.07$, respectively).

At 100 m and 480 m asl, *C. catoirii* and *C. capitata* were caught mainly during the

Table I.
Maximum abundance of *Ceratitis rosa*, expressed as fruit flies caught per trap and per day, on three strawberry guava feral stands at different elevations (Réunion Island) and for 2 years. Means within each column followed by the same letters are not significantly different (Tukey's multiple comparison test at the $p = 0.05$ level).

Site	Elevation (m above sea level)	Years	
		1993	1994
Grand-Brûlé	100	239.6 a	46.2 a
Piton Armand	480	26.7 b	18.8 b
Bras Pistolet	720	56.1 ab	25.6 ab

strawberry guava fruiting period (*figure 2*). At low elevation, populations were kept at a low level after the *P. cattleianum* harvest, particularly in 1994. This was probably due to other host plants. Neither species was trapped at 720 m. Population levels of *C. catoirii* and *C. capitata* were very low, 10 to 450 times less than those of *C. rosa*. They were much lower at 480 m than at 100 m asl.

3.2. fruit infestation

The infested fruit percentage increased rapidly during the fruit maturity period as did the fruit fly population (*figure 3*). At 100 m and 720 m asl, the infested fruit percentage was significantly correlated to the fruit fly abundance, but it was not at 480 m asl (*table II*). The infestation buildup was more rapid at low elevation. In the lowlands and the highlands, very high levels of infestation (>90 %) were sometimes reached at the end of the fruiting period. Nevertheless,

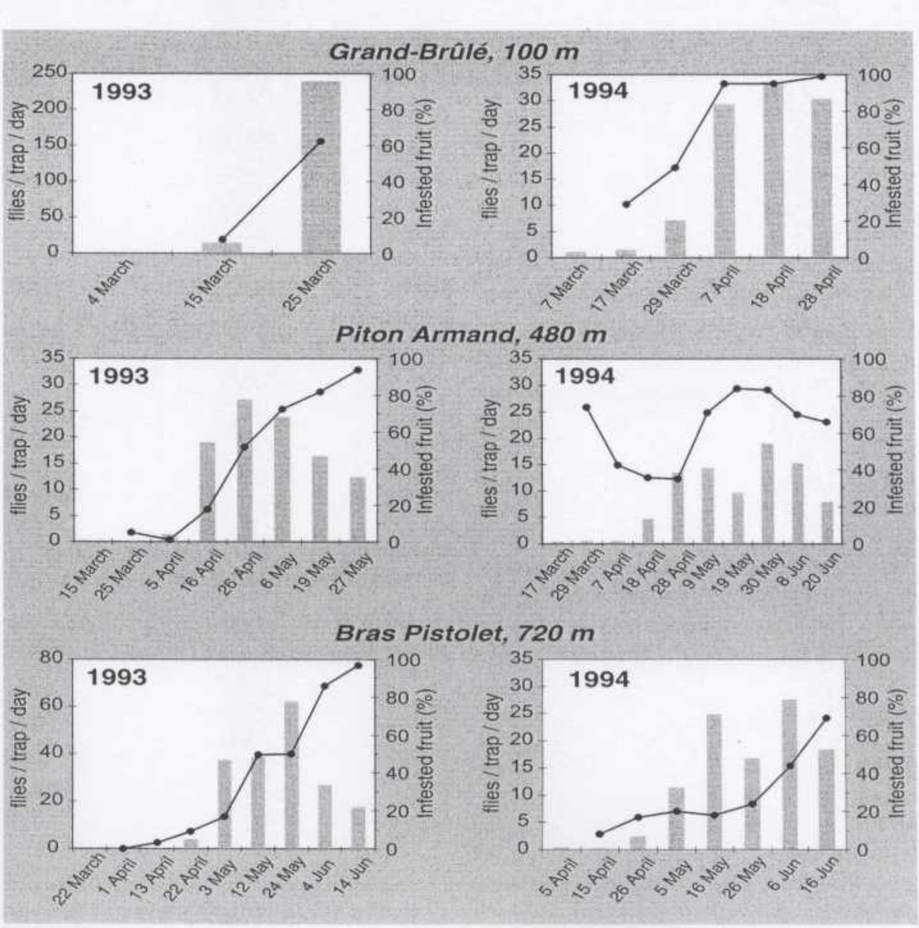

Figure 3.
Relation between *Ceratitis rosa* population, as indicated by the mean number of flies caught per trap and per day (vertical bars), and the percentage of infested fruit (line) during the 1993 and 1994 fruiting periods on three feral stands of strawberry guava located at different elevations.

no relation came out between the maximum fruit infestation and the elevation.

No damage was recorded on immature dark green fruit. Infestation began when fruit changed colour from green to yellow and red, i.e. 7 to 10 d before maturity and harvest. In fact, dissections of different maturity fruit showed that most punctured fruit had yellow and particularly red and dark red skin colour. Punctures containing eggs, though rarer, could also be observed when the fruit just started changing colour from dark to light green. At 480 m asl, the proportion of infested immature fruit was significantly higher in the middle of the fruiting period than at the beginning of this period; at 720 m, it was not different (*table III*). This proportion increased with the fruit fly abundance and with the global percentage of infested fruit. However, it appeared more in relation with the latter variable as the significantly higher proportion of infested immature fruit at Piton Armand coincided with the highest global percentage of infested fruit, but not with the highest fruit fly abundance which was reached at 720 m asl on 3 May 1993 (*table III*).

At 480 m and 720 m asl, in 1993, emergence of *C. rosa* from fruit was higher in the middle of the fruiting period (14.3 and 2.8 emerged flies / 100 fruit, respectively) than it was at the beginning (2.5 and 2.2 emerged flies / 100 fruit, respectively) (*table IV*). This pattern was similar to that of the infested fruit percentage (*figure 3*). The mean number of pupae (± *s*) obtained from single infested fruit was 2.0 ± 1.2 ($n = 62$), with a maximum of six pupae in a single fruit.

Fruit fly emergence data (*table IV*) showed that *C. rosa* is the main species in strawberry guava in Réunion Island over a large range of elevations. In the lowlands, few *C. catoirii* and *C. capitata* emerged. It is the first mention of *P. cattleianum* as host plant for the latter species in Réunion Island. At 480 m asl, none of these species emerged from the fruit collected on the site in 1993. But three *C. catoirii* flies emerged

Table II.
Kendall's tau correlation coefficients between the percentage of infested fruit and the fruit fly abundance during the 1993 and 1994 strawberry guava fruiting period on three feral stands located at different elevations in Réunion Island.

Site	Elevation (m above sea level)	Years	
		1993	1994
Grand-Brûlé	100	–[1]	0.70*
Piton Armand	480	0.14	0.17
Bras Pistolet	720	0.50*	0.62*

* Significant correlation coefficient ($p < 0.05$).
[1] Insufficient data to calculate Kendall's tau.

Table III.
Infested immature fruit proportion, infested fruit global percentage and fruit fly abundance of a sample taken on feral strawberry guava stands located at 480 m and 720 m asl in Réunion Island, at the beginning (first date) and in the middle (second date) of the fruiting period.

Site	Elevation (m asl)	Sampling date (1993)	Infested immature fruit (%)	Infested fruit (%)	Fruit fly abundance (flies/trap/day)
Piton Armand	480	5 April	4.3***	32.7	1.4
		26 April	57.7***	62.7	27.3
Bras Pistolet	720	13 April	0 ns	14.0	0.3
		3 May	31.8 ns	25.0	37.5

*** Proportions significantly affected by the sampling date ($p < 0.001$).
ns: proportions not significantly affected by the sampling date ($p > 0.05$).
asl: above sea level.

Table IV.
Strawberry guava fruit infestation with different *Ceratitis* species at three different locations in Réunion Island and in relation with different sampling dates.

Site	Elevation (m asl)	Sampling date	Number of fruit collected	Total number of pupae	Fruit fly emergence		
					C. rosa	*C. catoirii*	*C. capitata*
Grand-Brûlé	100	26 February, 1992	2 290	417	240	3	1
		10 March, 1993	2 499	44	27	–	–
Piton Armand	480	5 April, 1993	518	16	13	–	–
		26 April, 1993	495	199	71	–	–
Bras Pistolet	720	12 April, 1993	1 290	54	28	–	–
		3 May, 1993	574	58	16	–	–

asl: above sea level.

from a sample of 1 250 fruit collected in a nearby area in March 1992 (data not shown). Only *C. rosa* emerged from fruit collected at 720 m asl. These data corroborate the population dynamics pattern of *C. catoirii* and *C. capitata* at low and medium elevations.

4. discussion and conclusion

4.1. host phenology and *C. rosa* population dynamics

Though the Natal fruit fly is a tephritid of economic importance in many countries in southern and eastern Africa [12], this study is the first detailed account on its population dynamics in relation with one of its important host plants. Our results indicate that feral strawberry guava stands are important habitats during the fruiting period for *C. rosa* breeding. Outside this period, *C. rosa* population remains at a very low level with some temporary increases probably due to other unidentified host plants. *C. rosa* appears to be a temporary resident in the strawberry guava in relation with the seasonality of fruiting and probably the lack of other host plants able to produce as many fruit as strawberry guava does. This species presents many favourable factors as a breeding host plant: high density of trees, high number of fruit per tree and long duration of the fruiting period. As the strawberry guava fruiting period is conditioned by elevation, the entire area invaded by this species provides the Natal fruit fly with favourable breeding conditions from March to July. This could explain the development of large *C. rosa* populations when fruit mature.

In our study, no relation has been found between fruit fly abundance and temperature in the range of the mean temperatures measured during the fruiting period. Nevertheless, fruit fly abundances in the sites ranked in the same order during both years. This suggests that fly abundance could mainly be related to the fruit availability on the sites. However, above 1 000 m asl, fruit ripen in July and August when temperatures are relatively low (mean temperature in July and August at 1 000 m: 13.7 °C). These fruit are not infested by fruit flies (unpublished data), which suggests that cool temperatures could be a limiting factor to *C. rosa* activity. Further studies are necessary to confirm this hypothesis.

On the three sites, captures were lower in 1994 than in 1993, which indicates that this difference is related to the year. Various factors could be involved: climate (rainfall), fruit production, and other factors linked with *C. rosa* ecology. Their influences are not easy to evaluate and this is beyond the objectives of our study.

The rapid fruit fly population increase observed at the beginning of the fruiting period suggests that this development is due to the immigration of adults from other areas. The duration of *C. rosa* life-cycle is about 25 d at 25 °C under laboratory conditions [13]. Assuming that the effect of temperature is roughly the same in natural conditions, the contribution of emerged young flies to the total population occurs about 1 month after the first fruit infestation at low elevation where mean temperatures during the fruiting period are favourable. The still high fruit fly abundance after the strawberry guava fruiting period on this site could reflect the emergence of a new fruit fly generation which stays on other host plants.

At 480 m and 720 m asl, mean temperatures during the fruiting period are cooler and the duration of *C. rosa* life-cycle is therefore longer. The fruit fly abundance pattern with a double peak observed in 1994 on these sites (*figure 2*) could indicate the emergence of new fruit fly generations. *C. rosa* population decreases during the second half of the fruiting period when fruit abundance declines. Trap captures drop just after the end of harvest. This could reflect a beginning of migration to other places as breeding conditions become unfavourable: temperature drop, lack of fruit.

4.2. trap catches and fruit infestation

C. rosa females preferably sting yellow to dark red fruit, close to their full maturity. Immature dark green fruit which are very hard are never stung. The change of skin colour from dark green to light green is the beginning of the last steps of fruit development leading to full maturity. It is followed up by a fruit firmness and acidity decrease and a rise in sugar contents [14]. These changes, particularly fruit hardness, probably give favourable conditions for oviposition and larval development.

The fly population buildup increases competition for fruit resources. It induces a higher over-all percentage of infested fruit. The relation between the fruit fly population and the fruit infestation, even if it is significant in most cases, is not very strong (*table II*). The availability of mature fruit may affect the percentage of fruit infestation: if the number of fruit is low compared with the fruit fly population, the infestation pressure increases on the fruit which may be more infested. If mature fruit are strongly infested, *C. rosa* can increase its attacks on light green or green–yellow immature fruit. Such a behaviour can explain the high percentages of fruit infestation observed at the end of the fruiting period at 480 m and 720 m asl. Similarly, few ripe fruit at the beginning of the fruiting period at 480 m asl in 1994 lead to high levels of infestation in spite of a low fruit fly population (*figure 3*).

4.3. interspecific competition between *Ceratitis* species

In the studied biotopes, characterized by abundant rainfall and the strawberry guava dominance, trap catches and fruit infestation data indicate that *C. catoirii* and *C. capitata* populations are lower than those of *C. rosa*. In those biotopes, these two fruit fly species are captured only at low and medium elevations, and mainly during the strawberry guava fruiting period. In such conditions, a strong interspecific competition probably occurs among the three *Ceratitis* species, which turns to the benefit of *C. rosa*. The mechanisms of this competition still have to be explained (influence of abiotic factors, differences in biotic potential, host quality, host-marking pheromones, etc.) in further studies.

The low abundance of *C. capitata* is most probably related to the climate of the wet coast of the island, which is unfavourable for this species. *C. capitata* prefers dry areas and is commonly more abundant on the dry west coast of Réunion Island [10] where it may clearly be strongly dominant over the Natal fruit fly on some of its preferred host plants (Quilici et al., unpubl.). In Hawaii, abundance of *C. capitata* also appears to be related to rainfall, with trap catches higher in areas that receive little rainfall than in areas that receive abundant rainfall [4]. In another study, Harris et al. [5] observed that guava fruit (*Psidium guajava* L.) infestation by *C. capitata* was low in wet areas and higher in dry areas.

The climatic conditions of the two study sites at medium and particularly at low elevation are favourable for the endemic *C. catoirii* which prefers hot and wet conditions [9]. However, this species appears to be a poor competitor in the presence of *C. rosa*, even in its preferred biotopes. In the study sites, *C. catoirii* was generally more abundant than *C. capitata*, which corroborates the difference in habitat preference between the two species.

4.4. strawberry guava protection in orchards

If *C. rosa* occurrence in an agricultural strawberry guava orchard would be the same as in feral stands, our results are useful to define integrated pest management procedures against *C. rosa* in strawberry guava orchards. As immature dark green fruit are not infested, sprays during fruit growth are useless. When fruit begins to ripen, fly population has to be monitored with traps. Specific studies will be required to specify an intervention threshold. In the meantime, it is recommended that sprays should begin when the first fruit infestations appear or when trap catches steadily increase. The objective is to avoid the population buildup which leads to high fruit infestation. The application of bait-sprays has to be tested to reduce insecticide quantities.

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Fluctuaciones según temporada de las poblaciones de la mosca de frutas de *Psidium cattleianum* Sabine en la isla de la Reunión: fenología del huesped e infestación de frutas.

Resumen — Introducción. El guayabo-fresa, *P. cattleianum*, muy difundido por toda la isla de la Reunión, es una de las plantas huesped de diferentes especies de moscas de frutas. Se han estudiado las relaciones entre la dinámica de poblaciones de las moscas de frutas, la fenología de la planta huesped y los daños en las frutas. **Material y métodos**. De 1992 a 1994, se ha estudiado, según la estación del año, la evolución de la abundancia de las moscas de frutas, por medio de trampas, que engañan sexualmente. Ésto se ha realizado en trés zonas naturales para el *P. cattleianum*, situadas a 100 m, 480 m y 720 m de altura en la parte este y húmeda de la isla. Se destacaron daños en las frutas durante las cosechas. **Resultados**. La especie de la mosca de frutas más capturada en el conjunto de estos lugares ha sido la mosca del Natal, *Ceratitis rosa* Karsch. Sin embargo, la mosca de frutas mediterránea, *C. capitata* (Wiedemann), y la mosca de frutas de las Mascareignes, *C. catoirii* (Guérin-Mèneville), sólo han sido capturadas ocasionalmente a 100 m y a 480 m de altura. El guayabo-fresa confirma ser una de las plantas huesped para estas trés especies desde el nivel del mar hasta 500 m de altura, aunque con un obvio dominio de *C. rosa*. Más allá de 500 m, solamente se encontró esta especie en frutas dañadas. Las poblaciones de *C. rosa* eran débiles durante todo el año y aumentaron en las temporadas de cosecha del guayabo-fresa. La abundancia de *C. rosa* varió significativamente entre los lugares, aunque sin ninguna relación clara con la altura. **Discusión y conclusión**. Éstos resultados aportan nueva información sobre la dinámica de las poblaciones de la mosca del Natal en relación con una de sus principales plantas huesped. Los resultados son útiles para definir programas de tratamiento fitosanitario contra las moscas de frutas en vergeles comerciales de los guayabos-fresa.

Reunión / *Psidium cattleianum* / fenología / *Ceratitis* / dinámica de poblaciones / trampas / identificación / relaciones huesped parasito