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# EFFICIENCY OF DIFFERENT FOOD ATTRACTANTS IN TRAPS FOR THE MONITORING OF FRUIT FLIES DURING THE FRUIT CYCLE IN ORCHARDS IN THE REGION OF MACATE, MANICA, MOZAMBIQUE

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**ABSTRACT:** The use of traps built with local material for eliminating and monitoring fruit flies in rural orchards increases the development of the agricultural sector. The transfer of knowledge and mastery of exploration technologies currently used in this region are not used in rural regions of Mozambique. These traps will reduce the socioeconomic impact caused by the spread of fruit flies in rural areas, which is innovative for fruit-producing families. The aim of this study was to evaluate the efficiency of traps using alternative food attractants to capture fruit flies. The statistical design used was randomized blocks with three types of traps with different attractants, in a split-plot scheme, using four replicates, consisting of four blocks. A total of 23,276 fruit flies were collected from July 2015 to September 2016, of which 22,850 were Ceratites, batroceras, and Dacus and 426 lonquelids, representing 98.99% and 1.01%, respectively. Traps with fresh fish syrup showed better efficiency in capturing fruit flies, capturing 16,589 fruit flies during the evaluation period. Traps with sugar syrup captured 7,281 flies and orange juice showed the lowest results, with 4,454 flies. The highest population peak occurred in December and January, indicating population capable of colonizing other fruit trees.

**KEYWORDS:** Population fluctuation, Fruit flies, Rural fruit growing.

# EFICIÊNCIA DE DIFERENTES ATRATIVOS ALIMENTARES EM ARMADILHAS NO MONITORAMENTO DAS MOSCAS-DAS-FRUTAS DURANTE O CICLO DAS FRUTÍFERAS, EM POMARES NA REGIÃO DE MACATE, MANICA, MOÇAMBIQUE

**RESUMO:** O uso da armadilha construída com material local para eliminação e monitoramento das moscas das frutas em pomares rurais aumenta o desenvolvimento do setor agrário, e transferência de conhecimento e domínio das tecnologias de exploração em situação atual nessa região que não são usados em regiões rurais em Moçambique, essas armadilhas diminuirão o impacto socioeconômico causado pela dispersão da mosca de fruta nas área rurais, considerando que é algo inovadora nas famílias produtoras de fruteiras. Objetivou-se avaliar a eficácia de armadilhas usando atrativos alimentares alternativos na captura de moscas-da-fruta. O delineamento estatístico foi blocos casualizado com três tipos de armadilhas com diferentes atrativos, em esquema de parcelas subdivididas e quatro repetições, composta por 4 blocos. Foi coletado um total de 23.276 moscas de frutas no período de julho de 2015 a setembro de 2016, dos quais 22.850 adultos de Ceratites, batroceras, Dacus, 426 de lonqueídeos, representando 98,99%, 1.01% respectivamente. Assim sendo a armadilha de calda de peixe fresco teve melhor eficiência na captura de moscas-das-frutas, com maiores capturas de 16.589 no período de avaliação após a instalação das armadilhas nesses pomares. Enquanto as armadilhas com caldas de açúcar tiveram 7.281 na captura e suco de laranja foram a que tiveram menos resultados na eficiência de captura com 4.454. E o maior pico populacional ocorreu nos meses de dezembro e janeiro, indicando uma população apta a colonizar outras frutíferas.

**PALAVRAS CHAVE**: Flutuação populacional, Mosca das frutas, Fruticultura Rurais.

## INTRODUCTION

Fruit flies (Diptera: Tephritidae) are considered one of the main fruit tree pests in Mozambique, mainly regarding marketing and export due to quarantine restrictions imposed by fresh fruit-importing countries (Malavasi, 2000). Due to the high damage caused by fruit flies in fruit and horticulture, numerous quarantine barriers have been established in the trade between countries and regions. Multimillion campaigns have been developed in many countries to eradicate and minimize the damage caused by one of the main fruit growing pests, causing significant losses for this sector. The agricultural and agro-industrial activities with the greatest expansion in world trade, at the moment, are in the areas of fruit growing and fruit juices (Dias et al., 2018).

The region of Macate, located in the province of Manica, Mozambique, has gained evidence for the great advance in the exploitation of the fruit growing activity within the districts of the province. Soil conditions, climate and access to the urban market have favored the increase in the activity. The species B*actrocera invadens* and *Ceratitis capitata* are of great economic importance in Mozambique, considering that its climatic conditions allow, throughout the year, the existence of cultivated and wild fruits, favoring the survival and displacement of the pest from one plant to another (Tres, 2002).

The Tephritidae family is cosmopolitan; the lack of availability of hosts limits its distribution and extreme climatic conditions facilitate propagation. The species that have great economic importance in the destruction of fruits belong to five genera: Ceratitis, Anastrepha, Bactrocera, Dacus and Rhagoletis (Sugayama, 1995). The lack of information on safety measures for the application of insecticides, as well as their effects on the environment and human health predominate in rural areas, making it difficult for producers to control this pest (Argenta, 2007).

The first records of the use of trapping are those of Newell (1936), who reported the use of bell-shaped glass bottles with an invaginated opening at the bottom, containing, as bait, a mixture of orange juice and brown sugar, indicating progresses that had been made during the period from 1933 to 1934 to eradicate the infestation of *Anastrepha obliqua* and *Anastrepha suspensa* fruit flies in Florida (USA), Key West (Raga, 2006).

In recent years, there has been intensification of research on natural parasitism, infestation rates in hosts of fruit flies that increase the population flow, aiming at control and integrated management. Successful biological control programs can be found in several studies carried out around the world, which can facilitate the management of fruit flies, causing significant reduction in the initial population of these pests without the use of chemicals (Nascimento; Carvalho, 2000). The aim of the present study was to evaluate the efficiency of different food attractants and traps for the monitoring of fruit flies in orchards.

## MATERIAL AND METHODS

The Republic of Mozambique is located in the southeastern portion of the African continent, with the Indian Ocean to the east, Tanzania, Malawi and Zambia to the north, Zimbabwe and South Africa to the west, and Swaziland to the south, and experiments were located in the region of Macate, province of Manica, at coordinates -19°23'20.94" S 33°34'8.22" E. The research was carried out in four lychee and orange orchards in the period from June 2015 to September 2016, and the number of plants was 68 in orchard 1, 95 in orchard 2, 45 in orchard 3, and 82 in orchard 4. All orchards were conducted in a conventional manner, with lychee (*Litchi chinensis*) and orange trees (Citrus X sinensis), with average age of 10 years and spacing of 7.0 m x 5.0 m between rows and plants, and 7.0 m x 3.0 m between rows and plants, respectively. There are no commercial orchards in the region.

Orchards were kept clean throughout the research period, with no phytosanitary treatment, and with the pruning of old and diseased branches in early June 2015. Population monitoring of adult fruit flies was carried out through standard 1.5 or 2 L PET model bottles. Treatments (food attractants) used were: a) 100% sugar syrup in 40 g; b) sugary guava juice in 50g; c) fresh fish syrup (*Trachurus trachurus*) in 100g, installed in these orchards, with 48 traps in total.

The sugary guava juice was prepared according to methodology proposed by Rampazzo (1994), in which the pulp was boiled in water and sugar in the proportion of 400 ml of water and 200 ml of sugar for every six guava fruits. After boiling, the mixture was sieved and packed in 1500 ml bottles, being stored in refrigerator. When preparing solutions, the content of each bottle (500 ml) was diluted in water to form 1 L of juice.

In the experimental orchard, 3 treatments were installed, with 4 replicates and 4 plots that correspond to orchards positioned at height of 1.5 m from the ground, with plants taken randomly in the plot and with disposition towards the south side (S), as a way of mitigating the incidence of solar rays. Traps were kept in the field for 15 days, being collected and transported to the laboratory of the Department of Agriculture - Chimoio Agrarian Institute (IAC), to perform the screening and counting of insects by the process of "hydro-sifting". After one week, each trap received a new solution of the respective food attractant and were replaced in the plot in the same positions in which they were before.

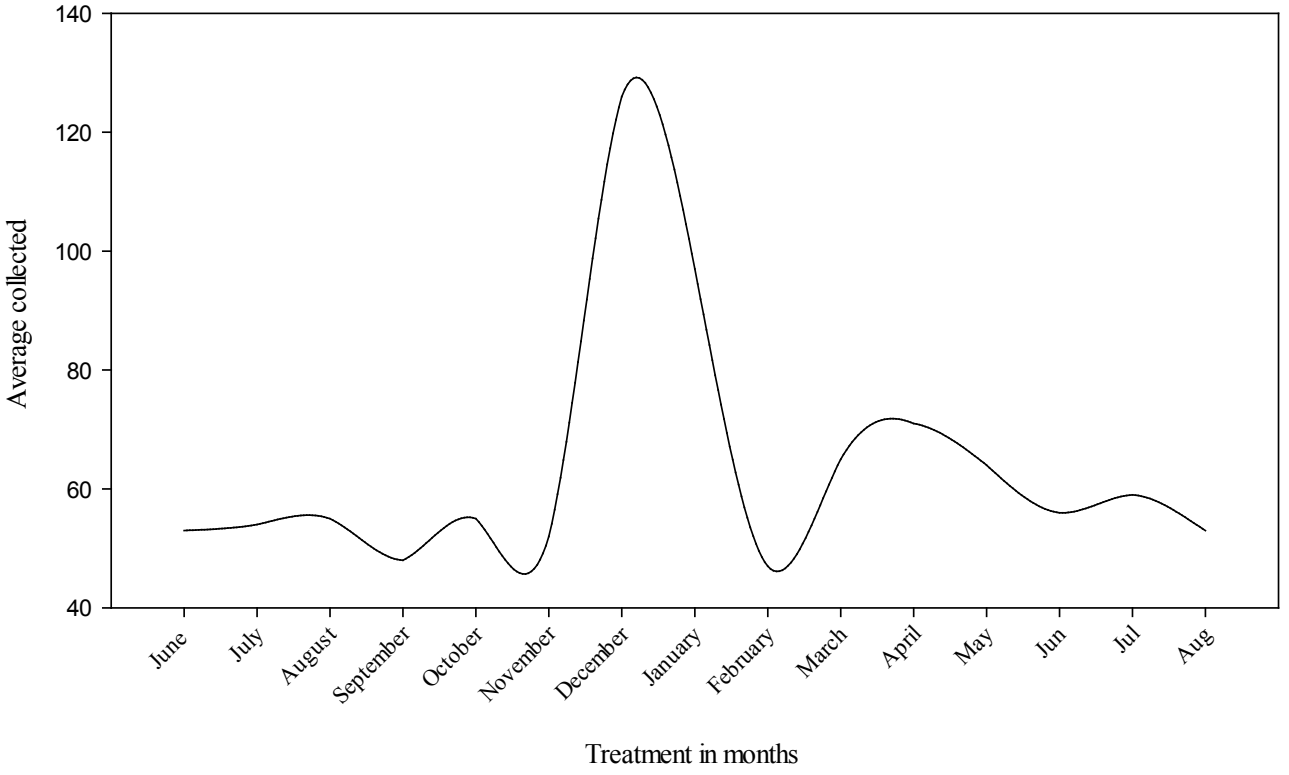
The research was conducted in a completely randomized design. The analysis of the population fluctuation of fruit flies was performed for the most frequent genera, considering the total number of females and males collected. Histograms were made to correlate population fluctuation and meteorological factors [minimum and maximum temperatures (°C), mean relative humidity (%) and accumulated rainfall (mm)]. For temperature and relative humidity values, averages of the 15 days during sampling were calculated, and for precipitation, the value accumulated in this period was used. Daily data referring to the analyzed meteorological elements were registered by the Meteorological Station of the city of Chimoio.

Data were submitted to analysis of variance and means were grouped by the Scott-Knott test, at 5% probability. Analyses were performed by the System for Analysis of Variance – SISVAR software (Ferreira, 2011).

## RESULTS AND DISCUSSION

The 1.5 L PET trap added with food attractant fresh fish (*Trachurus trachurus*), showed significant results in terms of adult capture in relation to the other treatments, flies/traps/sample date, between June 2015 and August 2016 (Figure 1).

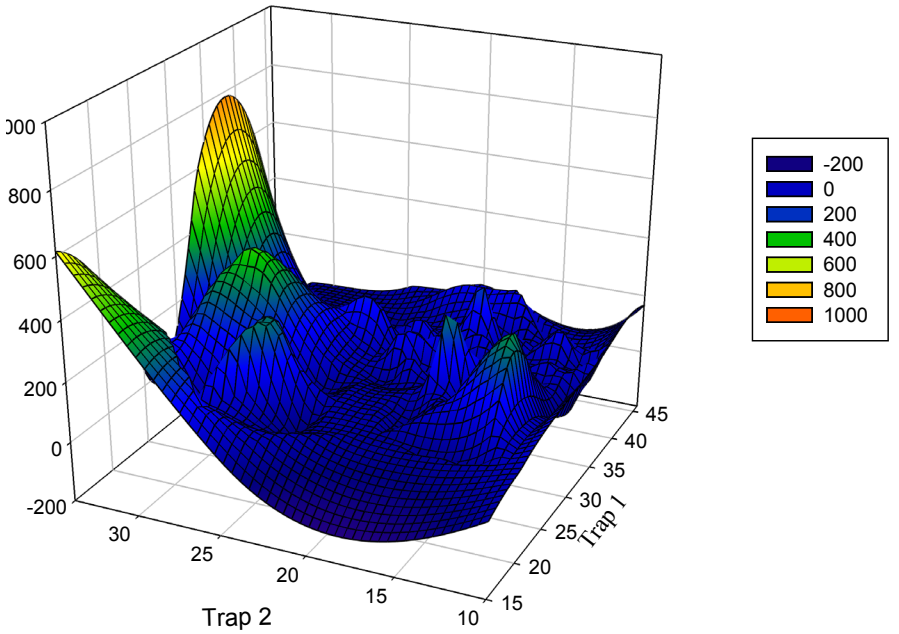
**Figure 1.** Population fluctuation of adult fruit flies collected using 1.5-liter PET bottle traps containing different food attractants in rural orchards – Macate, 2015-2016.




Regarding the capture of adults, treatment with sugar syrup showed no significant difference in relation to the use of fresh fish syrup (*Trachurus trachurus*) for dates of 12/15/2015 and 01/12/2016, flies/trap/sample date (Figure 2). Therefore, the use of PET bottle traps with fresh fish syrup was responsible for capturing greater number of adults for these collection dates, flies/trap/sample date for both collections.

Studies carried out by other authors such as Araújo et al. (2008); Alvarenga et al. (2009); Chavarria et al. (2009); Montes et al. (2011); Duarte et al. (2013) obtained similar results. The high population density of fruit flies in the period with the presence of ripe fruits may be related to the emission of volatile compounds that certain fruit species have in this period, attracting tephritids through the similarity that the compounds present when compared to the sex pheromones of these dipterans (Dutra et al., 2009).

**Figure 2.** Average number of adults collected in traps with three different attractants (sugar syrup, guava sugar juice, fresh fish syrup) at different sampling occasions in orchards of Macate – Manica, 2015/2016.




High population density of these tephritids was observed in the months of December and January (Figure 1), which is explained by the fact that it was a period of hosts of fruit flies near orchards being evaluated, and observing the averages of these months, significant difference was observed compared to other months, in which no difference was observed. Related studies have reported that the high tephritid population density in this period may be related to the type of host, and increased proliferation is related to the presence of a permanent preservation forest, unlike commercial orchards, where there is greater control and frequency of species *Ceratitis capitata* and *Anastrepha* (Duarte et al., 2013).

The population fluctuation of tephritid adults was related to the presence of ripe fruits, with high population peaks comprised between December 2015 and January 2016, when sampled with 1.5-liter PET traps added with food attractants fresh fish syrup, 100% sugar syrup, sugary guava juice. Bactrocera fruit fly was first detected in Mozambique in 2007 in Cuamba, Niassa, and its presence and dispersion triggered the imposition of quarantine measures that restrict the movement and export of products, namely vegetables and fresh fruits, representing the loss of potential markets for export and domestic marketing of these products (Cugala, 2011).

This population capture ratio was evaluated in a period of high infestation, which coincides with high prolificity (December 2015 to January 2016) (Figure 1 and 2). The infestation levels varied in number of density and percentages of 30% and 50% were analyzed. The graph illustrates the capture density; the ordinate axis shows trap 3 and the abscissa axis shows trap 1, trap 2 respectively. Population peaks for fruit flies varied greatly from week to week. Infestation rates were also variable; however, to a lesser extent for the genus Ceratites. In addition, an ever-increasing trend in infestation levels was observed each week, making it difficult to establish the relationship between infestation and population fluctuation.

The presence of sexually immature fruit flies during the post-harvest period of fruit suggests that there is more than one generation in each harvest, thus corroborating results of Salles (1995), who found that the species is multivoltine, being population peaks related to many and other hosts multiplier of these species.

Based on results, it was possible to verify and the average of treatment with fresh fish syrup was high and significant, a fact that probably occurred due to the greater efficiency of this food attractant. The average value of treatment with sugary guava juice was low, but the average value of treatment with sugar syrup was high in relation to treatment with sugary guava juice (Table 1). The low population density of fruit flies, even in the presence of ripe fruits or in the maturation phase, may be related to the interaction of the population of these tephritids with biotic and abiotic factors, which may have been responsible for directly or indirectly influencing samples collected during the experimental period (Souza et al., 2008).

**Table 1.** Average number of adult fruit flies collected in 1.5L bottle PET traps with different food attractants in an orchard of Macate – Manica, 2015/2016.

| Treatments | Averages | Test results |
|---|---|---|
| Sugary guava juice (2) | 32.037500 | a1 |
| 100% sugar syrup (1) | 44.829167 | a1 |
| Fresh fish syrup (3) | 114.070833 | a2 |
| CV 1 (%) | | 74.76 |
| CV 2 (%) | | 53.41 |

a1,2 Means followed by the same letter in columns do not differ from each other at 5% significance level by the Tukey's test; CV: coefficient of variation.

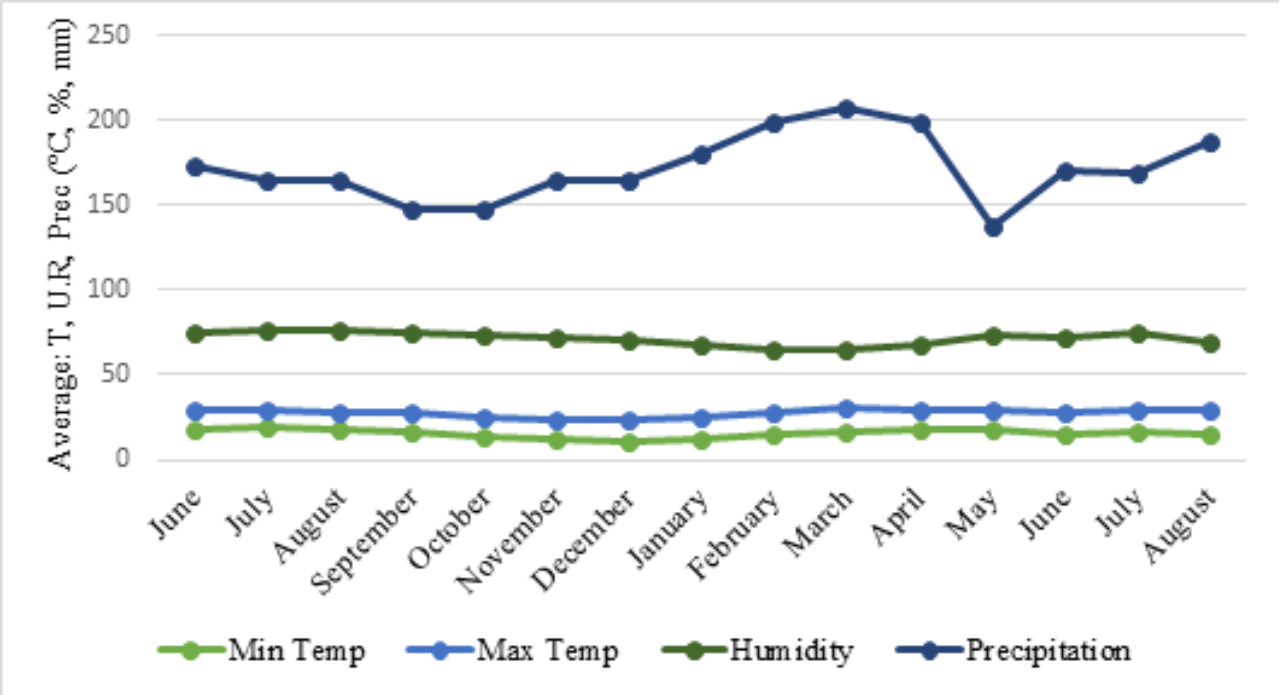
This difference in treatments may be related to a greater abundance of fruits in the orange orchard, greater selection in this environment or even to subspecific variation within each genus or species of fruit fly. According to Jaldo et al. (2001), the natural environment favors fruit flies to find greater diversity of primary and secondary substances to compose their diet in their life cycle, which can increase their reproductive performance.

It was observed that fruit flies had three generations according to their life cycle, from three to four weeks, which increased the number of fruit flies in orchards, thus having higher frequency in each trap, with average of 1.26 flies (Figure 2). Therefore, the damage in orchards was caused almost exclusively by the genus Dacus. According to Souza and Nascimento (1999), the infestation rate of fruit flies is an important indicator of the population level, as it allows establishing the status of the host plant in terms of susceptibility to pest attack under certain soil and climate conditions.

Although the stages of fruit development in the field were not evaluated, a comparison was made between orange and lychee orchards, and it was observed that there was great variation in the proportion of fruit flies at different stages of insect development, and in relation to the stage of fruit development, the presence of flies showed an almost non-existent difference in the stage of green fruits.

The high population density of adult fruit flies was influenced by abiotic factors related to meteorological elements such as temperature, and the fluctuation of these factors impacted the insect's reproductive cycle (Figure 3). For Plácido-Silva et al. (2005), climatic factors directly influence the insect's biological cycle, which can result in variations in the number of annual generations and in the population density of the pest. In tropical climate regions, the temporal fluctuation of adult fruit flies is basically related to the presence of host plants, which feed in the pre-oviposition period to guarantee the insect greater development of reproductive structures (Corsato, 2004).

**Figure 3.** Meteorological factors influencing fruit fly population density: minimum temperatures [T. min. (°C)] and maximum [T. Max. (°C)], average relative humidity [R.U. (%)] and accumulated rainfall [Prec. (mm)]. Macate – Manica, 2015-2016.




Regardless of the different types of attractants used, fresh fish syrup (*Trachurus*) showed efficiency and the highest capture percentage of Dacus and Ceratitis in relation to traps with sugary guava juice, orange juice, and is transparent in the capture of different fruit fly species using fresh fish syrup as attractant in the proportion of 1 to 2 fish per bottle, bringing positive effects for a period of 7 and 15 days after the trap installation, being able to properly replace it in the monitoring of these insects in commercial or domestic orchards.

The period of highest population peak in the region under study was between December and January; therefore, planting fruit trees close to host cultures susceptible to fruit flies requires integrated management with the highest possible care so that the population level does not increase.

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