Population Fluctuation of Fruit Flies (Diptera: Tephritidae) in Domestic Orchards in the Paraíba Swamp Region, Brazil

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ABSTRACT

Knowledge about the population fluctuation of fruit flies (Diptera: Tephritidae) is an important tool for control methods adoption as recommended by Integrated Pest Management (IPM). The objective of the research was to evaluate the fruit flies population fluctuation in eight domestic orchards from Paraíba swamp region and to correlate this information with the plant phenology as well as the meteorological elements. This research was developed in two rural properties of each municipality, georeferenced, identified according to fruit species diversity criterion. Adult fruit flies capture were realized by plastic traps containing 300 mL of 5.0% hydrolyzed protein aqueous solution (Bio Anastrepha®) as food attractant. Climatic data were obtained daily by thermo hygrometers and through the Executive Agency of Water Management of the State of Paraíba - AESA. During the study period, a total of 3.159 fruit flies were collected, with 10 species belonging to the genus Anastrepha and C. capitata species. Fruit flies infestation was observed monthly for both genera, *Anastrepha* and *Ceratitis*, however, this first stood out in the whole year. The MAD index in a few municipalities was superior to 0.5 being recommended to do fruit flies control in these areas. The seasonal occurrences, as well as the *Tephritidae* infestation rates in the domestic orchards are related to the availability of fruits.

1. INTRODUCTION

In Brazil, fruit production occurs in all regions, but it predominates in tropical and subtropical climates, where phytosanitary problems represent one of the main obstacles to the expansion of fruit production. The outlook for the sector is optimistic, therefore it is necessary to develop strategies to control pests that compromise production and/or exports [1].

25

26   Among the pests, which can be defined as any species, race or plants biotype, animals or pathogen

27   vectors, fruit flies are prominent because of their destructive potential. These insects are considered to

28   be the biggest fruticulture pest in the world, it is easily adaptable when introduced in another region

29   and, in many cases, can compromise up to 100.0% of production [2]. Knowledge about the population

30   fluctuation and the time of greatest occurrence of a certain fruit flies species economically important

31   are indispensable requirements in order to establish an efficient and rational control since they allow

32   being feasible the planning of effective management strategies [3].

33

34   Several factors, such as climate, altitude, geographic location, phenology and host succession

35   (primary or secondary), may influence the abundance of certain species of fruit flies throughout the

36   year [14]. An example is the population explosions of some species of *Anastrepha* at certain times of

37   the year, with peaks of the density of adult individuals directly related to hosting phenology and their

38   high reproductive potential, while other species, such as *A. fraterculus*, do not develop at temperatures

39   below 10 ºC and above 35 ºC [5].

40

41   Traps usage allows to verify these insects population fluctuation and to relate them to the abiotic

42   factors, mainly those associated to the climate, helping to define the seasons of the greater or lesser

43   probability of infestations [6]. Despite the growing advent of tephritid research in the country over the

44   years, information about the bioecology of fruit flies is still scarce in several regions [7]. Thus, the

45   objective of this study was to evaluate the population fluctuation of fruit flies in the Paraíba swamp

46   region and to correlate this information with plant phenology and meteorological elements.

47

48   **2. MATERIAL AND METHODS**

49   The study area is located in the Mesoregion of the Agreste of Paraíba and Microregion of the swamp

50   of Paraíba including the municipalities of: Alagoa Grande (S 07° 01 '53.6 "W 035° 38' 12.1"), Alagoa

51   Nova (S 07° 04' 56.3 "W 035° 48' 53.1"), Areia (S 06° 59' 22.7 "W 035° 44' 00.2"), Bananeiras (S 06°

52   43' 44.3 "W 035° 39' 24.0"), Borborema (S 07° 06' 40.0 "W 035° 49' 10.5"), Pilões (S 06° 56' 45.4 "W

53   035° 39' 38.2") and Serraria (S 06° 49' 03.8 "W 035° 39' 19.4"). The research was developed in two

54 rural properties of each municipality, georeferenced, identified according to fruit species diversity

55 criterion. Population survey was carried out from July 2015 to June 2016.

56

57 Adult fruit flies were obtained with the aid of plastic traps (PET), two traps/plants were installed in each

58 sampling areas. The traps were placed at the mid-height of the tree canopy and contained 300 mL of

59 an aqueous solution of hydrolyzed protein up 5.0% (Bio Anastrepha®) as food attractant.

60

61 The flasks were inspected biweekly, the occasion that captured fly specimens were collected and food

62 attractants were replaced. These specimens were washed with water in a sieve and then packed in

63 plastic containers with 70.0% hydrated alcohol, properly labeled and then sent to the Laboratory of

64 Invertebrate Zoology of the Agricultural Sciences Center of the Federal University of Paraíba -

65 Areia/PB, where the males and females of the *Anastrepha* and *Ceratitis* genuses were screened and

66 stored in 70.0% hydrated alcohol for later species identification.

67

68 The specimens of fruit flies were separated by sex and only the females were identified through the

69 aculeus of the ovipositor, since the males did not present the diagnostic characters for the specific

70 identification [8], using identification keys [9]. The females collected from the *Anastrepha* genus were

71 identified by Dra. Clarice Diniz Alvarenga Corsato - State University of Montes Claros, Janaúba, MG.

72

73 *Anastrepha* and *Ceratitis* species surveys for this study of population fluctuations were carried out

74 through individuals collected in the PET traps, during a period of one year, the necessary time to carry

75 out the species population fluctuation in the orchards.

76

77 Population fluctuation was based on the total number of adults *Anastrepha* and *Ceratitis* per month,

78 where the value obtained was determined by the sum of the number of male and female adults

79 captured in the four weeks of the referred month, being analyzed in relation to climatic variables:

80 temperature, relative humidity, and rainfall.

81

82　The climatic data were obtained daily by thermo hygrometers (temperature and humidity) arranged in

83　the properties of each city, and rainfall data by the Executive Agency for the Management of Waters of

84　the State of Paraíba - AESA.

85

86　The MAD index was calculated using the formula (captured flies number/traps installed

87　number/collection days number) [10].

88

$$MAD = \frac{N}{A \times D}$$

89

90　At where:

91　MAD = fly/trap/day;

92　N = total number of captured flies;

93　A = number of evaluated traps;

94　D = interval between collections in days.

95

96　**3. RESULTS AND DISCUSSION**

97

98　During the study period, from July 2015 to June 2016, a total of 3,159 fruit flies were collected, of

99　which 85.57% belonged to the genus *Anastrepha*, being (1.867 females and 836 males) and 14.43%

100　the species *Ceratitis capitata* (Wied.), being (330 females and 126 males). Fruit flies were captured

101　each month on all year round in eight municipalities of Paraíba swamp region, which are: Alagoa

102　Grande (131), Alagoa Nova (471), Areia (614), Bananeiras (625), Borborema (345), Matinhas (65),

103　Pilões (131) and Serraria (777), respectively.

104

105　In order to evaluate the areas of domestic orchards in Paraíba swamp region, the of population

106　fluctuation analysis was carried out using only data related to the females, where during the year a

107　total of 10 species of the genus *Anastrepha* were captured: *A. fraterculus* (864), *A. obliqua* (535), *A.*

108 *distincta* (24), *A. dissimilis* (11), *A. pickelli* (1), *A. antunesi* (37), *A. sororcula* (382), *A. zenildae* (11), *A.*

109 *hadropickeli* (1), *A. barbiellinii* (1) and the species *C. capitata* (330).

110

111 An infestation of fruit flies was observed for both genera12 months of the year however, the genus

112 *Anastrepha* presented the most of species in relation to the genus *Ceratitis*. The highest fruit flies

113 population peaks occurred in April/2016 for the following species and municipalities: *A. obliqua* (147)

114 in Serraria, *A. fraterculus* (91) in Areia, *A. sororcula* (58) in Bananeiras, these also were species

115 present in all municipalities every month of the year (Figure 1).

116

117 These population peaks occurred in the period of intense rainfall in those municipalities, where a

118 positive correlation was observed about rainfall (r = 0.50, P> 0.05, r = 0.47, P> 0.05, r = 0.53, P> 0.05)

119 in the tephritid populations (Table 1). During the period from December/2015 to January/2016, the

120 lowest catch of fruit flies individuals were observed (Figure 1). This lower capture of flies is possibly

121 due to biotic factors (natural enemies, predators, and competition) and abiotic factors (rainfall,

122 temperature, and air humidity) which influence the life cycle of the tephritids [11].

123

124 Population peaks of fruit fly species occur according to the reproductive phenology and their host fruit

125 maturation. According to several authors, fruit availability was a determining factor for the occurrence

126 of fruit flies larger populations, proving that the fruiting is the phenological component that contributes

127 the most for these insects population increase [12,13].

128

129 The population low catches are due to the unavailability of host plants for these *Tephritidae* all over

130 the sampling period in the orchards study areas for species such as *A. distincta, A. dissimilis, A.*

131 *pickelli, A. antunesi, A. zenildae, A. hadropickeli* and *A. barbiellinii*, thus justifying perhaps their low

132 density, since some studies demonstrated that most of a certain fruit flies species remain around its

133 preferred host [14].

134

135 *Anastrepha fraterculus* was the species with the highest number of individuals collected and was

136 present in all orchards, at all seasons of the year, having the highest catch rate in the month of

September/2015. The population fluctuation graph of *A. fraterculus* was similar throughout the 12 months of the collection in practically all the municipalities, in relation to the peaks and the low population density (Figure 1). Increases in the population were observed in the fruiting and maturation periods of guava, the abundant fruit in all orchards.

About of all meteorological factors evaluated, the temperature presented the lowest correlation with fluctuation, ranging from r = -0.48 to 0.22 P> 0.05. The negative correlation between temperature and fruit fly infestation in guava orchards in Mossoró, and also found that in the months where the temperature was above 28 ⁰C there was no fruit fly infestation on fruits and trap capture rates were insignificant [10].

According to [15], climatic factors separately analyzed present little interference in the fruit fly population, indicating that these factors need to be studied together to determine their population density, a compatible fact with the results obtained in this work, where temperature and relative humidity barely interfere in the fruit flies population, but in a significant way.
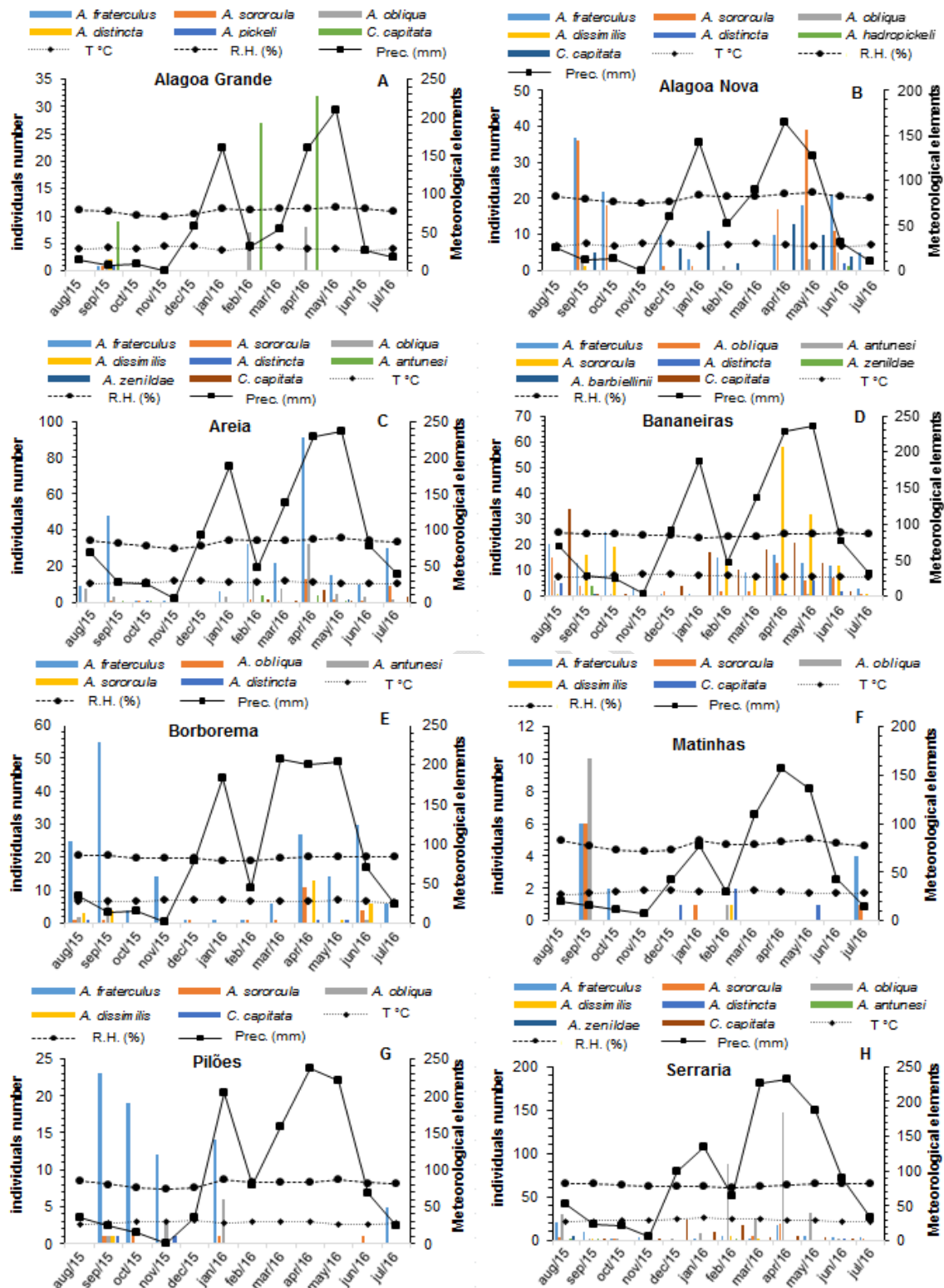
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Figure 1. Fruit flies population fluctuation of *Anastrepha* and *Ceratitis capitata* species
obtained from Fly-Hunting Traps in domestic orchards, from July/2015 to June/ 2016 in Paraíba
swamp region

168

Table 1 - Pearson correlation analysis between the abiotic factors (temperature, rainfall, and relative humidity) and the average density of fruit flies trapped in orchards during the period from July/2015 to June/2016 in Paraíba swamp region

Fatores abióticos	Alagoa nova		
	R	T	P
Temperature (°C)	-0.18 NS	-0.59	P < 0.05
Relative humidity (%)	0.18	0.59	P < 0.05
Precipitation pluvial (mm)	0.14	0.44	P < 0.05
	Alagoa Grande		
Temperature (°C)	0.12	0.39	P < 0.05
Relative humidity (%)	0.23	0.76	P < 0.05
Precipitation pluvial (mm)	0.18	0.56	P < 0.05
	Areia		
Temperature (°C)	-0.19 NS	-0.57	P < 0.05
Relative humidity (%)	0.46 *	1.6	P < 0.05
Precipitation pluvial (mm)	0.47 *	1.68	P < 0.05
	Bananeiras		
Temperature (°C)	-0.48 NS	-1.73	P < 0.05
Relative humidity (%)	0.38 *	1.28	P < 0.05
Precipitation pluvial (mm)	0.53 *	1.98	P < 0.05
	Borborema		
Temperature (°C)	-0.26 NS	-0.86	P < 0.05
Relative humidity (%)	0.66 *	2.76	P < 0.05
Precipitation pluvial (mm)	0.00	0.00	P < 0.05
	Matinhas		
Temperature (°C)	-0.04 NS	-0.12	P < 0.05
Relative humidity (%)	-0.16 NS	-0.52	P < 0.05
Precipitation pluvial (mm)	-0.32 NS	-1.06	P < 0.05
	Pilões		
Temperature (°C)	0.05	0.15	P < 0.05
Relative humidity (%)	-0.39 NS	-1.36	P < 0.05
Precipitation pluvial (mm)	-0.35 NS	-1.19	P < 0.05
	Serraria		
Temperature (°C)	0.22	0.71	P < 0.05
Relative humidity (%)	-0.20 NS	-0.65	P < 0.05

Precipitation pluvial (mm)	0.50 *	1.84	P < 0.05

172 * Significant p <0.05.

173

174 Was considered in the MAD index (flies/trap/day) the total number of specimens of the genera

175 *Anastrepha* and *Ceratitis* in the orchards of eight municipalities studied.

176

177 The tephritids number collected per trap per day evidenced that during the year catches had variations

178 in all localities and in certain samples obtained monthly the index was zero and higher than 1.0

179 (Figures 2). According to the specific standard for area of low prevalence of fruit flies of FAO, it defines

180 that MAD levels established for the most diverse cultures concerning phytosanitary issues are

181 undertaken by an NPPO (National Plant Protection Organization) of producing and importing

182 countries, since these vary according to the susceptibility of the host and the region where the

183 cultivation is carried out [16].

184

185 For this work, the MAD index 0.5 was used as a basis for orchards analyses, since it is the level used

186 for decision making, indicating the need for intervention with some control method [17]. The control

187 level in fruit orchards is established by the number of flies caught per trap per day (MAD), with the

188 indexes being MAD 0.5, MAD 0.8 and MAD 1.0, thresholds for control through insecticides [18].

189

190 The highest rates of fruit fly catch were recorded in the months of February/2016 and April/2016. The

191 municipality of Serraria was the city with the highest catch rate, which had an impact on the high MAD

192 index, presenting two population peaks, one in February/2016 (MAD = 0.7) and another in April/2016

193 (MAD = 1.12). The above-cited fact was similar in the cities of Areia and Bananeiras, where the

194 highest catch rates were registered in April/2016 with MAD = 1.05 and MAD = 0.6 respectively (Figure

195 2).

196 The MAD index in these localities was superior to 0.5 indicating high infestation in the orchards, with a

197 recommendation to control fruit flies in these areas. These results are in agreement with the results

198 found by [3], where MAD ranged from 0.5 to 2.0, a study conducted in the state of Amazonas. The

199   results obtained with this study are also similar to those found by [19], who studied the diversity of fruit

200   flies in the UFAM Campus, obtaining MAD from 0.89 to 3.69.

201

202   In the municipalities of Alagoa Grande, Alagoa Nova, Matinhas, Pilões and Borborema, fruit flies

203   population fluctuation did not present a capture rate equal to or greater than 0.5 fly/trap/day at any

204   time of the year, however the orchard located in the municipality of Alagoa Nova reached MAD levels

205   of 0.42 and 0.43 in the months of September/2015 and May/2016 respectively, these levels found in

206   these months are already recommended to start to carry out some measure of control for this pest. It

207   should be noted that in this study the influence of biotic factors was no assessed, such as parasitism,

208   predation, and competition which together with abiotic factors are responsible for the regulation of the

209   fruit flies population fluctuation throughout the year. Fruit fly population monitoring is an important

210   resource for integrated pest management in commercial fruit trees, allowing to verify the population

211   fluctuation and the economic damage level [20]. The information obtained from the capture of fruit flies

212   in traps for monitoring is important for decision-making at the beginning and at the end of control

213   measures besides allow to evaluate the effectiveness of the strategies adopted [19].

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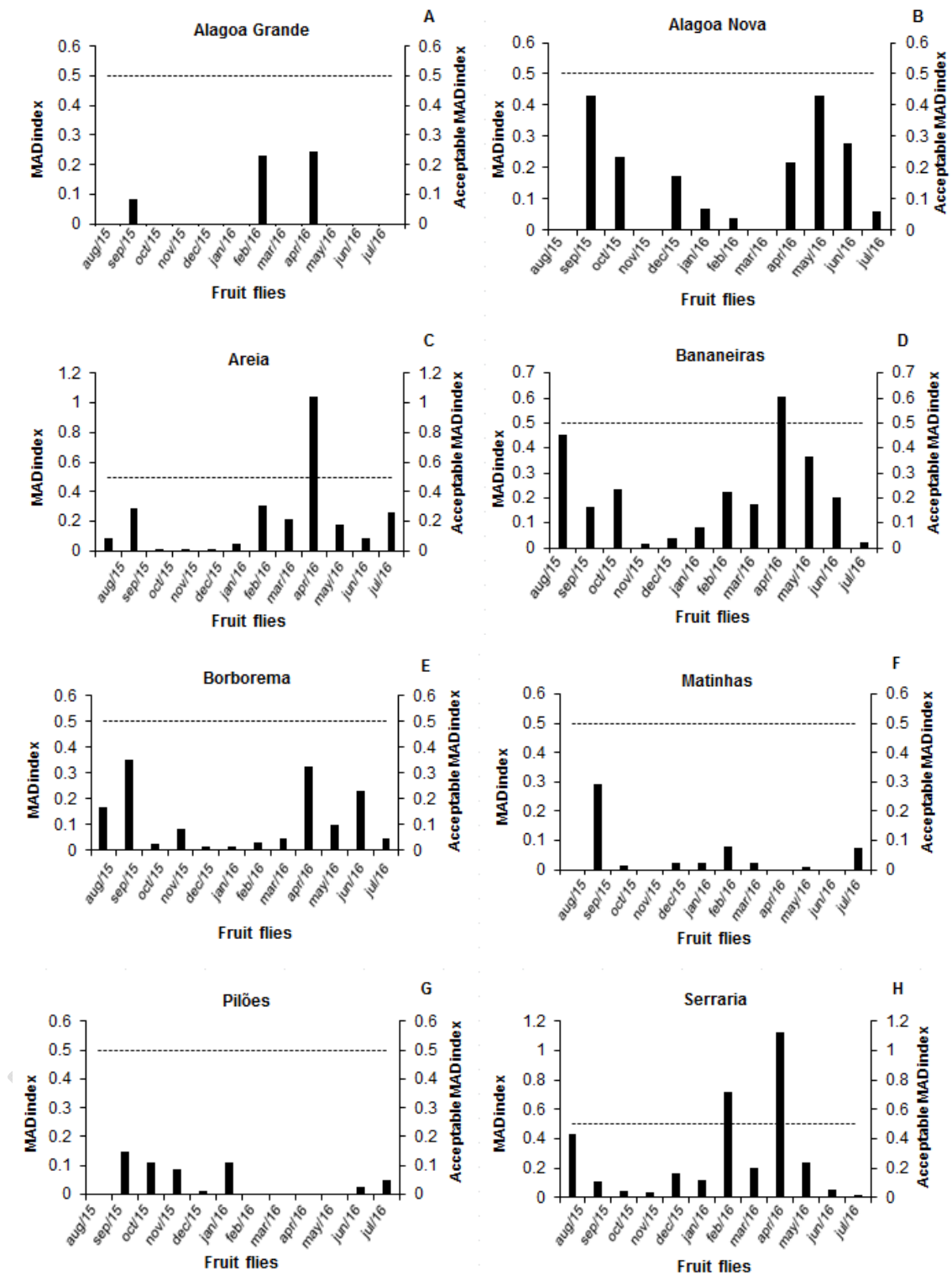
Figure 2. MAD index (flies/trap/day) of fruit flies obtained in Fly-Hunting traps in domestic orchards, from July/2015 to June/2016, in Paraíba swamp region

4. CONCLUSIONS

The low catches of certain species of fruit flies (*A. distincta, A. dissimilis*, *A. pickeli*, *A. antunesi*, *A. zenildae*, *A. hadropickeli*, *A. barbiellinii*) are due to the occurrence of alternative hosts around the orchards. The MAD index in the municipalities of Serraria, Areia and Bananeiras, in April/2016 was higher than 0.5 and it is recommended to control fruit flies in these areas. The seasonal occurrence is related to the availability of fruits, as well as the tephritid infestation rates in the domestic orchards.

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