ECOLOGY, BEHAVIOR AND BIONOMICS

Populational Fluctuation of Frugivorous Flies (Diptera: Tephritoidea) in Two Orange Groves in the State of Mato Grosso do Sul, Brazil

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Flutuação Populacional de Moscas Frugívoras (Diptera: Tephritoidea) em Dois Pomares de Laranjas do Estado de Mato Grosso do Sul

RESUMO - Este trabalho avaliou a captura de moscas frugívoras (Tephritidae e Lonchaeidae) com armadilhas plásticas McPhail, em dois pomares comerciais de citros, localizados nos municípios de Anastácio e Terenos, Estado de Mato Grosso do Sul. Os objetivos foram estudar a flutuação populacional dos adultos capturados nas armadilhas e verificar qual a relação entre as espécies amostradas nas armadilhas com os frutos danificados. As armadilhas foram distanciadas cerca de 30 m entre si sobre toda a área, penduradas a aproximadamente 1,70 m de altura, na copa das plantas de citros. Foram instaladas oito armadilhas (duas armadilhas/ha) no pomar em Anastácio e 21 armadilhas em Terenos (uma armadilha/ha). As armadilhas foram iscadas com a proteína hidrolizada de milho (5%) Tephritid^{MR} (atrativo alimentar). As avaliações foram feitas no período de 22 de março de 1994 a 23 de março de 1996. A mosca-do-mediterrâneo *Ceratitis capitata* (Wiedemann) e 25 espécies de *Anastrepha* foram capturadas em vários meses nas armadilhas, mas não infestaram laranjas. *Neosilba* sp. foi capturada ininterruptamente durante os 25 meses e foi encontrada, também, nos frutos danificados amostrados nos pomares. Isso sugere que *Neosilba* sp. pode ter importância econômica em citros. As espécies de moscas frugívoras predominantes foram *Neosilba* sp., *C. capitata*, *Anastrepha punctata* Hendel e *A. sororcula* Zucchi. Não houve correlação entre o número de adultos de moscas frugívoras capturadas nas armadilhas com o número de larvas e de adultos criados das laranjas infestadas colhidas nos pomares.

PALAVRAS-CHAVE: Mosca-das-frutas, armadilha McPhail, *Anastrepha*, *Ceratitis capitata*, *Neosilba*

ABSTRACT - This paper evaluated the capture of frugivorous flies (Tephritidae and Lonchaeidae) with plastic McPhail traps, in two commercial citrus groves, located in the municipalities of Anastácio and Terenos, in the state of Mato Grosso do Sul, Brazil. The aim of this work was to determine the populational fluctuation of adult frugivorous flies, and to study its relationship with the damaged fruits in the groves. The traps were placed about 30 m apart over the entire area in both groves, hung up approximately 1.70 m high from soil, in the canopy of the citrus plants. Eight traps were installed (two traps/ha) at Anastácio and 21 traps in Terenos (one trap/ha). The traps were baited with the hydrolyzed corn protein (5%) Tephritid^{TM} (food bait). Evaluations were carried out from March 22, 1994 to March 23, 1996. *Ceratitis capitata* (Wiedemann) and 25 species of *Anastrepha* were caught during several months in both orange groves, but no fruit fly species were found infesting oranges. *Neosilba* sp. was caught from the traps during all the experiment and was also reared from the damaged oranges, thus suggesting that that fly can be a pest. The predominant species of frugivorous flies caught in the traps were: *Neosilba* sp., *C. capitata*, *Anastrepha punctata* Hendel and *A. sororcula* Zucchi. There was no correlation between adult frugivorous flies caught in the traps and the number of larvae and adult flies reared from the infested oranges collected in the groves.

KEY WORDS: Fruit fly, McPhail trap, *Anastrepha*, *Ceratitis capitata*, *Neosilba*

The frugivorous larvae of *Anastrepha* spp., *Ceratitis capitata* (Wiedemann) (Tephritidae) and some species of the genera *Neosilba* and *Dasiops* (Lonchaeidae), are very abundant in the Neotropical Region, causing serious damage to the production of fruits and vegetables (Peñaranda *et al*. 1986, Sánchez *et al*. 1991, Zucchi 2000). The knowledge of the populational fluctuation of these species in each biome is an important requirement for the adoption of an effective strategy of pest control in the agroecosystems.

Since the early 30's, McPhail traps have been successfully used in many countries to survey and to study fluctuation of fruit flies and frugivorous lonchaeids population (Korytkowski & Ojeda 1971, Steyskal 1977, Borge & Basedow 1997). However, there is a lack of knowledge concerning whether or not the species captured in McPhail traps are related to those that are attacking the cultivated fruits and vegetables.

This study presents data on populational fluctuation of frugivorous flies captured in plastic McPhail traps hung up in two orange groves (*Citrus sinensis*), located in two different areas. The number of adults captured in the traps was compared with the number of larvae and adults obtained in oranges collected from the trees.

Material and Methods

McPhail Traps Captures. The orchards were located at Chácara Laranjal (20º 31' 36'' S / 55º 50' 12'' W, 170m), Anastácio and at Chácara Suzuki (20º 26' 12'' S / 55º 04' 54'' W, 308 m), Colônia Jamic, Terenos, MS. The two areas are located in different ecosystems and the distance between them is about 110 km. Chácara Laranjal is located in a transition between Cerrado and Pantanal of Taboco and the Chácara Suzuki is located in a typical ecosystem of Cerrado. In the orange grove of the Chácara Laranjal, eight traps were hung (two traps/ha) and 21 traps in the Chácara Suzuki (one trap/ha). The traps were baited with the hydrolyzed corn protein (5%) Tephritid™ (food bait), supplied by the Laboratório de Moscas-das-Frutas, Departamento de Biologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, SP.

The traps were about 30 m apart over the entire area. They were hung approximately 1.70 m high in the interior of the canopy. They were checked weekly on the same day of the week. All the captured insects were transferred to labeled vials containing 90% alcohol, for later identification. After each service, the traps were washed and the bait was renewed. The work was carried out in the two groves, from March 22, 1994 to March 23, 1996.

The first identification of the insects captured in the traps was done at the Laboratório de Controle Biológico de Insetos, Universidade Federal de Mato Grosso do Sul (UFMS) in Aquidauana, where all Tephritidae, Lonchaeidae and Otitidae were recorded. Insects other than those were discarded. The insects were fixed in alcohol 70% and identified in the Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura " Luiz de Queiroz" (ESALQ),Universidade de São Paulo, Piracicaba, SP.

The climatic data were obtained from the Section of Meteorology of EMBRAPA Gado de Corte, Campo Grande, MS. The data were used in the population studies of both groves (Anastácio and Terenos, MS), which are respectively 100 km and 25 km far from the meteorological station.

Voucher specimens of the frugivorous tephritoids and their parasitoids are deposited in the zoological collection of the Universidade Federal de Mato Grosso do Sul (ZUFMS), in Campo Grande, MS and in the collection of the Departamento de Entomologia, Fitopatologia e Zoologia Agrícola (ESALQ).

Collection of Fruits. Oranges were collected weekly on the same day that the traps were renewed, from March 22, 1994 to March 23, 1996. The sampling process consisted of a random inspection of one plant/ha in the Chácara Suzuki and two plants/ha in the Chácara Laranjal. Fruits with signs of infestation, e.g., oviposition punctures, were picked up and brought to the Laboratório de Controle Biológico de Insetos, Universidade Federal de Mato Grosso do Sul, at Aquidauana. They were counted, weighed and conditioned to obtain the 3rd-instar larvae (L3) and the adult flies or their parasitoids, according to methodology described by Uchôa-Fernandes & Zucchi (1999). When the amount (total biomass) exceeded the capacity of the laboratory, a random sample was taken, equal or superior to 20% of the total biomass, which was designated the biomass sample. This sample was maintained for rearing insects associated with the fruits. Temperature and relative humidity were not controlled in the laboratory.

The indices of infestation of larvae were calculated by fruit and by kg of fruit. The correlation analyses were made for monthly number of wild flies captured in the traps, larvae and adults reared from fruits and meteorological factors (temperature, relative humidity and rainfall). Pearson correlation was calculated between wild flies caught in the traps *versus* number of 3rd-instar larvae and flies reared from sampled oranges collected a month later. This time is equivalent to the period of development of immature frugivorous teprhitoids into adults.

Results and Discussion

The traps captured 25 species of *Anastrepha*, *C. capitata* and lonchaeids of the genera *Dasiops*, *Lonchaea* and *Neosilba*. However, only larvae and adults of *Neosilb*a sp. were obtained from oranges sampled during two consecutive harvesting seasons (March 1994 to March 1996). The data reinforce the idea that the McPhail trap with food bait is a good tool for sampling the diversity of species of frugivorous flies of an area, as already evidenced by several authors (Nascimento *et al*. 1982, Calza *et al*. 1988, Celedonio *et al*. 1995). However, it also indicates that flies being collected in McPhail traps hung up in groves are not necessarily those attacking the cultivated fruits (Norrbom & Kim 1988) (Table 1).

Fruit Infestation. At Anastácio, the index of infestation ranged from no larva (Nov. 1994 to Jan. 1995; Oct. to Nov. 1995) to 8.25 larvae per fruit (Jul. 1995), with an average rate of 1.95 larvae per fruit for the 25-month period. For that index as well as for the index larvae per kg of fruit, the months of greater infestation (larvae per kg of fruit) were June 1995 (25.0), July 1995 (51.8) and December 1995 (34.2) (Table 2 and Fig. 1).

Table 1. Frugivorous flies (Diptera: Tephritoidea) caught in 29 McPhail traps hung up in two groves of *C. sinensis* and reared from oranges naturally infested (Chácara Laranjal, Anastácio and Chácara Suzuki, Terenos, MS, March 1994 to March 1996).

Family and species	McPhail Traps	Orange fruits	Months of occurrence
Tephritidae			
Anastrepha alveatoides Blanchard	7	0	Sep.-Jan.
A. bezzii Costa Lima	1	0	Sep.
A. castanea Norrbom	1	0	Dec.
A. daciformis Bezzi	29	0	July-Jan.
A. dissimilis Stone	113	0	All months
A. distincta Greene	2	0	March-Aug.
A. fraterculus (Wiedemann)	20	0	April, May, July, Aug.
A. grandis (Macquart)	1	0	July
A. haywardi Blanchard	3	0	March, July
A. leptozona Hendel	1	0	Sep.
A. macrura Hendel	4	0	Jan., Sep., Oct.
A. montei Costa Lima	8	0	April, June-Aug.
A. obliqua (Macquart)	11	0	Jan., June-Sep., Dec.
A. pickeli Costa Lima	17	0	Jan.-March, May, Aug., Sep.
A. punctata Hendel	35	0	Jan., June-Dec.
A. rheediae Stone	8	0	Feb., May, Aug.
A. serpentina (Wiedemann)	1	0	Feb.
A. sororcula Zucchi	42	0	Jan.-April, June-Nov.
A. striata Schiner	20	0	Feb., April-Sep.
A. turpiniae Stone	6	0	March, April, July-Sep.
A. undosa Stone	2	0	Oct.
A. zenildae Zucchi	6	0	Jan., May, Sep., Nov.
Anastrepha sp. n.1[1]	1	0	Dec.
Anastrepha sp. n.2[1]	1	0	Jan.
Anastrepha sp. n.3[1]	1	0	Jan.
Ceratitis capitata (Wiedemann)	414	0	Feb.-Dec.
Lonchaeidae			
Neosilba sp.	5,966	1,671	All months

[1]Being described by M.A. Uchôa-Fernandes & R.A. Zucchi

The grove in Terenos showed a seasonal pattern of fruit infestation similar to that located in Anastácio, although with higher levels, varying from 0 (Oct.1994 and Aug. to Nov. 1995) to 11.5 larvae per fruit in May 1995, with an average of 3.95 larvae per fruit for the two year period. Regarding the index of larvae per kg of fruit, the greater infestation levels occurred in February 1995 (35.5), March 1995 (40.0), May 1995 (104.6) and July 1995 (66.7), with a mean of 17.7 larvae/kg of fruit during the two harvesting seasons (Table 3 and Fig. 2).

Larval Survival. It was similar in both groves. In Anastácio, the larval survival ranged from 0% (Nov. 1994 to Jan. 1995; Oct. and Nov. 1995, and Feb. 1996) to 98% (Jun. 1994, with 96% Jun. 1996), with an average throughout the period of 53.8% survival. During warmer months in the laboratory, more than 35ºC could be registered and this high heat could have affected the larval development. In months of mild temperatures (March to August), larval survival was higher than that from September to February, when the heat is very intense (Table 2). For the sampled fruits from Terenos, larval survival varied from 0% (Oct. and Dec. 1994; Feb. 1995 and, Aug. to Dec. 1995) to 100% (July 1994 and June 1995), with a total average of about 51%. Also, during the months with lower temperatures (Apr. to Jul.), survival was higher. On the other hand, during the warmer months in the laboratory in Aquidauana (Sep. to Mar.), larval survival was very low, suggesting a possible effect of the temperature in the laboratory on the larvae of *Neosilba* sp. (Table 3).

Except for six Otitidae (two in Anastácio and four in Terenos), all the flies reared from the oranges belonged to the genus *Neosilba*. These findings suggest that *Neosilba* sp. could play an important role in the economy of *Citrus* orchards.

There was not any correlation between the number of adult frugivorous flies caught in the McPhail traps and the number of larvae and adults from oranges naturally infested in the groves (Fig. 3 and Tables 4 and 5). There was also no effect of meteorological factors in the capture of the species of *Neosilba* in the McPhail traps. This last aspect agrees to observations by Aluja *et al*. (1996) who found no relationship between rainfall and the capture of fruit flies in traps in commercial mango orchards in Mexico.

Table 2. Monthly sampled biomass of oranges *C. sinensis* cv. Pera-Lima, infested by *Neosilba* sp. (Chácara Laranjal, Anastácio, MS, March 1994 to March 1996).

Months (1994 o1996)	Total biomass of fruit (kg)	Biomass sample (kg)	Nº of fruits	Nº of 3rd instar larvae (L3)	Index L3 by fruit	Index L3 by kg of fruits	% of larval viability and (nº of reared adults)	Number of specimens (n) of *Neosilba* sp.
1994 March (2 weeks)	5.24	5.24	41	112	2.73	21.37	94 (105)	105
April	15.38	15.38	127	285	2.24	18.53	90 (256)	254
May	29.55	11.81	82	98	1.20	8.30	85 (83)	79
June	26.41	5.29	37	49	1.32	9.26	98 (48)	48
July	8.15	5.14	35	58	1.66	11.28	88 (51)	51
Aug.	25.10	6.00	32	92	2.88	15.33	77 (71)	70
Sep.	9.49	5.80	40	100	2.50	17.24	44 (44)	41
Oct.	0.71	0.71	5	4	0.80	5.63	25 (1)	1
Nov.	0.22	0.22	1	0	0	0	0	0
Dec.	0	0	0	0	0	0	0	0
1995 Jan.	0	0	0	0	0	0	0	0
Feb.	0.91	0.91	6	6	1.00	6.59	67 (4)	4
March	3.80	3.80	27	46	1.70	12.11	87 (40)	40
April	17.75	12.31	84	149	1.77	12.10	96 (143)	143
May	9.43	9.43	61	175	2.87	18.56	86 (150)	134
June	1.08	1.08	7	27	3.86	25.00	96 (26)	26
July	1.91	1.91	12	99	8.25	51.83	87 (86)	86
Aug.	1.20	1.20	8	5	0.63	4.17	60 (3)	3
Sep.	0.43	0.43	3	7	2.33	16.28	43 (3)	3
Oct.	0.21	0.21	2	0	0	0	0	0
Nov.	0.23	0.23	2	0	0	0	0	0
Dec.	2.86	2.86	21	98	4.67	34.27	8 (8)	8
1996 Jan.	1.37	1.37	10	28	2.80	20.44	39 (11)	11
Feb.	0.58	0.58	4	7	1.75	12.07	0	0
March (3 weeks)	6.34	6.34	42	73	1.74	11.51	74 (54)	54
Total	168.35	98.25	689	1,518				1,161
Mean					1.95	13.27	53.76	

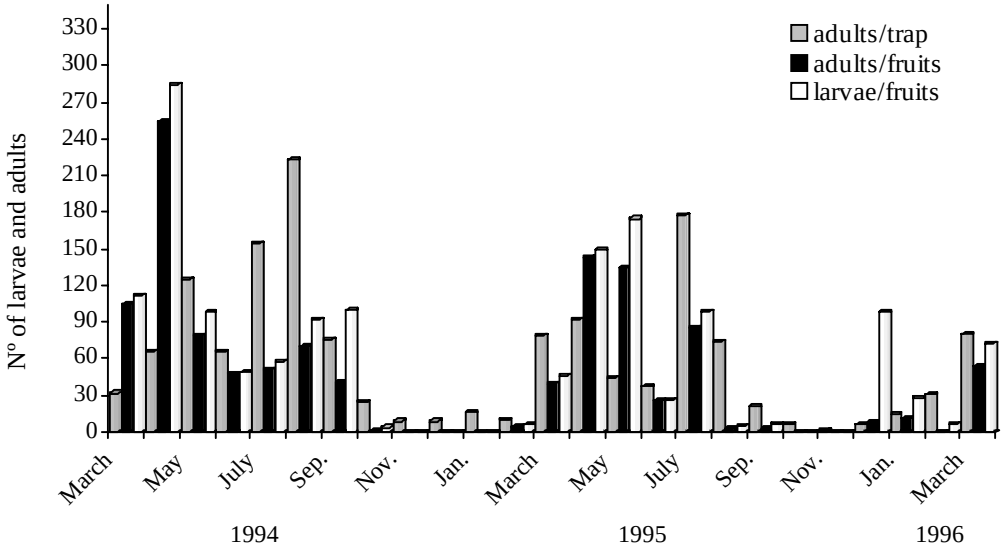

Figure 1. Populational flutuation of 3rd-instar larvae and adults of *Neosilba* sp. infesting orange and adults caught in McPhail traps in the grove of *C. sinensis* (Chácara Laranjal, Anastácio, MS, March 22, 1994 to March 23, 1996).

Table 3. Monthly sampled biomass of oranges *C. sinensis* cv. Pera-Lima and Pera-Natal, naturally infested by *Neosilba* sp. (Chácara Suzuki, Colônia Jamic, Terenos from March 1994 to March 1996).

Months (1994 to 1996)	Total biomass of fruit (kg)	Biomass Sample (kg)	Nº of fruis	Nº of 3rd instar larvae (L3)	Index L3 by fruit	Index L3 by kg of fruits	% of larval viability and (nº of reared adults)	Number of specimens (n) of *Neosilba* sp.
1994 March (2 weeks)	18.24	18.24	116	290	2.50	15.90	90 (261)	232
April	4.10	4.10	24	40	1.67	9.76	85 (34)	34
May	3.90	3.90	20	48	2.40	12.31	92 (44)	43
June	2.16	2.16	12	32	2.67	14.81	87 (28)	28
July	2.15	2.15	10	16	1.60	7.44	100 (16)	15
Aug.	3.60	3.60	20	33	1.65	9.17	91 (30)	30
Sep.	0.60	0.60	3	2	0.67	3.33	50 (1)	1
Oct.	0.17	0.17	1	0	0	0	0	0
Nov.	0.16	0.16	1	3	3.00	18.75	33 (1)	1
Dec.	0.62	0.62	3	1	0.33	1.61	0	0
1995 Jan.	17.50	17.50	6	149	24.83	8.51	7 (10)	10
Feb.	0.31	0.31	1	11	11.00	35.48	0	0
March	0.60	0.60	3	24	8.00	40.00	71 (17)	17
April	2.05	2.05	10	19	1.90	9.27	95 (18)	18
May	0.22	0.22	2	23	11.50	104.55	96 (22)	15
June	0.17	0.17	1	6	6.00	35.29	100 (6)	6
July	0.12	0.12	1	8	8.00	66.67	87 (7)	7
Aug.	0	0	0	0	0	0	0	0
Sep.	0	0	0	0	0	0	0	0
Oct.	0.15	0.15	1	0	0	0	0	0
Nov.	0	0	0	0	0	0	0	0
Dec.	0.91	0.91	5	3	0.60	3.30	0	0
1996 Jan.	2.43	2.43	9	38	4.22	15.64	21 (8)	8
Feb.	1.53	1.53	9	35	3.89	22.88	89 (31)	31
March (3 weeks)	2.33	2.33	7	17	2.43	7.30	82 (14)	14
Total	48.27	48.27	265	798	-	-	-	510 *Neosilba* sp.
Mean	-	-		-	3.95	17.68	51.04	-

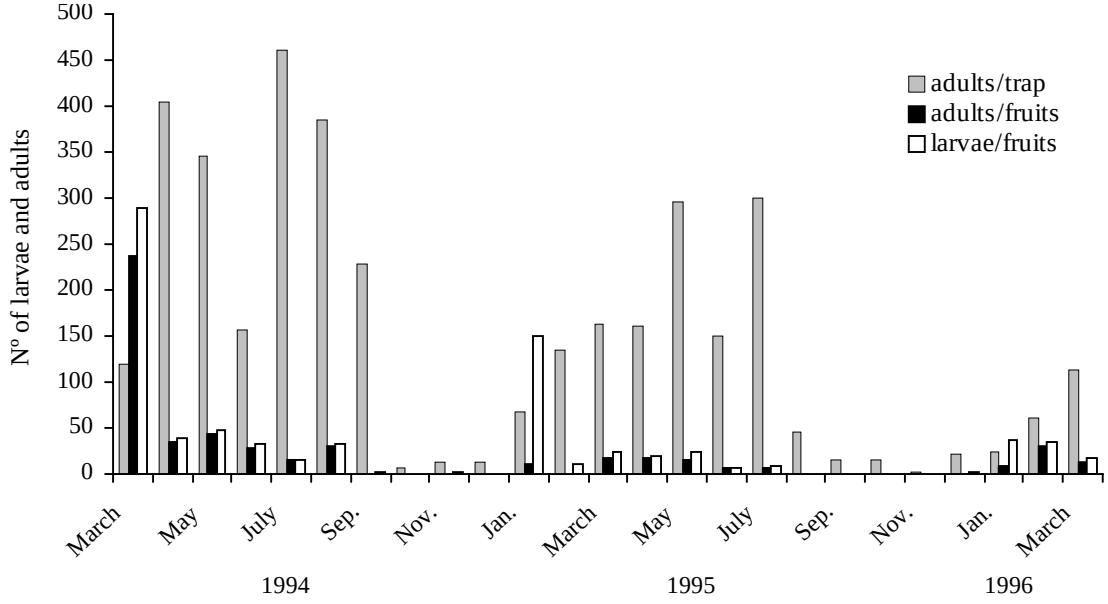

Figure 2. Populational flutuation of 3rd-instar larvae and adults of *Neosilba* sp. infesting orange and, adults caught in McPhail traps in the grove of *C. sinensis* (Chácara Suzuki, Colônia Jamic, Terenos, MS, March 22, 1994 to March 23, 1996).

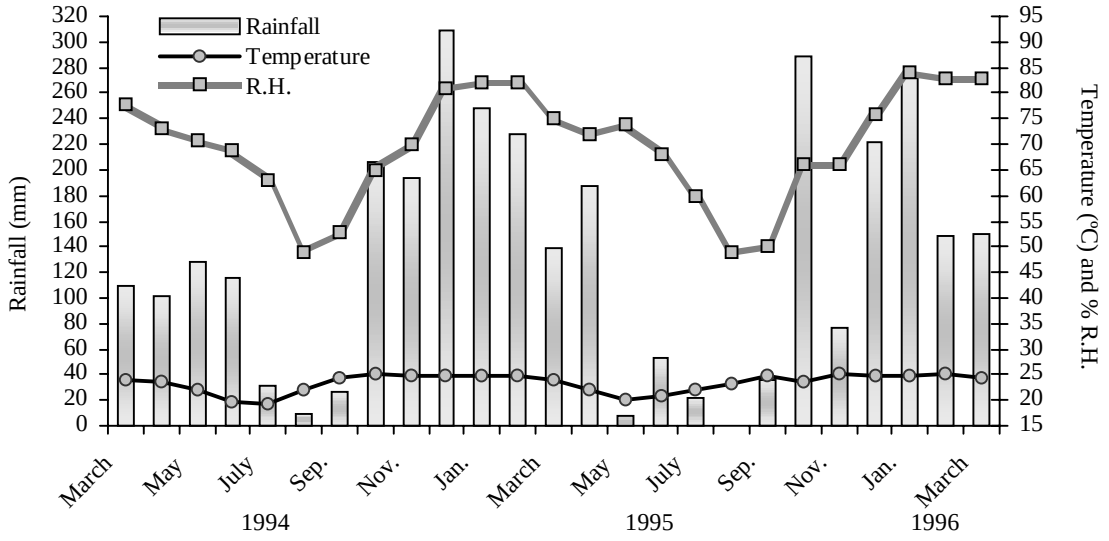

Figure 3. Climatic data from March 22, 1994 to March 23, 1996.

Table 4. Correlation between the number of adults *Neosilba* sp. caught monthly in plastic McPhail traps *versus* the number of 3rd-instar larvae and adults reared from oranges, and the climatic data in a grove of *C. sinensis* cv. Pera-Lima (Chácara Laranjal, Anastácio, MS, from March1994 to March 1996).

Tested correlations	Value of		
	r	t	P
Nº of adults caught in traps *versus* the nº of adults reared in oranges	1.446	0.6855	0.5067 n.s
Nº of adults caught in traps *versus* the nº of 3rd instar larvae from oranges	0.1856	0.8860	0.6111 n.s
Nº of adults caught in traps *versus* monthly mean temperature	-0.5790	3.3311	0.0033 n.s
Nº of adults caught in traps *versus* % R.H. monthly mean	-0.5059	2.7511	0.0113 n.s
Nº of adults caught in traps *versus* monthly precipitation accumulated	-0.5823	3.3596	0.0031 n.s

n.s. = Not significant at 5% of probability, according to the Tukey test.

Table 5. Correlation between the number of adults *Neosilba* sp. caught monthly in plastic McPhail traps *versus* the number of 3rd-instar larvae and adults reared from oranges, and the climatic data in a grove of *C. sinensis* cv. Pera-Lima and Pera-Natal (Chácara Suzuki, Terenos, MS, from March 1994 to March 1996).

Tested correlations	Value of		
	r	t	P
Nº of adults caught in traps *versus* the nº of adults reared in oranges	0.4243	2.1976	0.0367 n.s.
Nº of adults caught in traps *versus* the nº of 3rd instar larvae from oranges	-0.0385	0.1806	0.8524 n.s.
Nº of adults caught in traps *versus* monthly mean temperature	-0.6879	4.4459	0.0004 n.s.
Nº of adults caught in traps *versus* % R.H. monthly mean	-0.2291	1.1044	0.2811 n.s.
Nº of adults caught in traps *versus* monthly precipitation accumulated	-0.5579	3.1531	0.0048 n.s.

n.s. = Not significant at 5% of probability, according to the Tukey test.

C. capitata and 25 species of *Anastrepha* were captured, in several months of the year in the McPhail traps. However, the oranges were not attacked by these species. The predominant frugivorous flies in the traps were: *Neosilba* spp., *C. capitata*, *A. punctata* and *A. sororcula*. The species of *Neosilba* was captured in the traps in every month. Only *Neosilba* sp. was reared from the sampled oranges. Although the methodology used was not sufficient to state that *Neosilba* sp. is a primary pest, the data indicate a need for further research to verify the real importance of this fly in *Citrus* groves.

From the larvae of *Neosilba*, 77 parasitods emerged (Figitidae: Eucoilinae), being one specimen (1.3%) of *Aganaspis nordlanderi* Wharton, 24 specimens (31.2%) of *Trybliographa infuscata* Gallardo, Díaz & Uchôa-Fernandes (Gallardo *et al*. 2000) and 52 specimens (67.5% out of total) of *Lopheucoila anastrephae* (Rhower).

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