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Occurrence and Parasitism of Aphids (Hemiptera: Aphididae) on Cultivars of Irrigated Oat (*Avena* spp.) in São Carlos, Brazil

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ABSTRACT

The interactions between aphids and their Hymenopteran parasitoids on irrigated oats as well as the response of different cultivars of cereals regarding the resistance to these aphids and the influence on the host/parasitoid relationships were studied during two years in São Carlos, Brazil. Rhopalosiphum padi *(L.) was the predominant aphid observed throughout the study, while the other species were rarely found. Five species of parasitic Hymenoptera were found: three primary parasitoids*, Lysiphlebus testaceipes (Cresson*)*, Aphidius colemani (Viereck) *and* Diaeretiella rapae (M'Intosh) *and two hyperparasitoids*, Syrphophagus aphidivorus (Myer) *and* Alloxysta brassicae (Ashmead). *The UPF 86081 cultivar presented significant results regarding lower* Rhopalosiphum padi *contamination and higher aphid parasitism rates than those observed on some other cultivars. No significant effect on the percentage variation of parasitoid emergence on the mummified aphids was observed throughout this study.*

Key words: Aphids, biological control, oats, parasitoid, plant resistance

INTRODUCTION

Oat (*Avena* spp.) (Poaceae) is a very common winter culture cereal used in Brazil for grain production, fodder, hay, ensilage and winter green manure, which precedes the implantation of summer cultures (Baier et al., 1988). Among the pest-insects that usually cause greater damages to oat crops, the aphids attract special attention. These insects inoculate toxic substances of saliva on the plants, originating wrinkling, deformation and lumps, and many aphids might even be a virus vector to the plants (Zucchi et al., 1993).

According to Painter, cited by Lara (1991), plants may have one or more of the following three forms of resistance to a pest attack: non-preference to food, egg laying or shelter; antibiosis - adverse effect on the insect, such as weight, survival or fecundity decreasing; and tolerance - when the plant supports the insect attack. The basis for identification of the resistance type is on the plant's characteristics, as they follow a certain pattern, beginning with non-preference. A cultivar presents the non-preference type of resistance when it is not as used by the insect as another cultivar under equivalent conditions.

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There is evidence that natural enemies may keep aphid populations at low levels, preventing economical damages on cereal cultures (Giller et al., 1995). The microhymenopterans parasitoids play an important role in this process. These insects lay one single egg inside the host-aphid and as its larva grows, it destroys the host's tissues, leaving its exoskeleton with a peculiar aspect known as mummy (Tavares, 1991). In 1978, the use of parasitoids of cereal aphids was authorized in Brazil aiming the biological control of aphid populations, by introducing species proceeding from the Middle East, Europe and the South American Southern Cone (Zúñiga and Salinas, 1982). However, a negative behavior has been observed, since the biological control of the aphid populations by aphid parasitoids is hindered by secondary parasitoids or hyperparasitoids, hymenopterans, which destroy and replace the larvae within the mummies, emerging from these later. This results on the necessity of spotting and identifying these secondary parasitoids.

Chemical stimuli are the most important elements on the process of locating the host, which involve finding its habitat, recognizing and attacking the host. Aphids respond to volatile compounds, produced by the plants from which they get food (Powell and Zhang, 1983). That may be the most common means of locating aphids through their parasitoids (Bundemberg, 1990).

This article presents a survey on aphid populations, and their parasitoids observed on the cycle of oat cultures, and the analysis of resistance of the different cereal genotypes to those aphids, as well as *Avena sativa* cutivars influence on the host/parasitoid relationship.

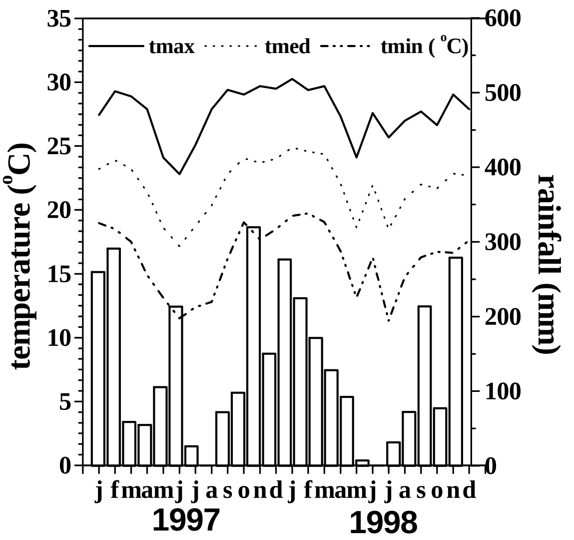
MATERIALS AND METHODS

This study was conducted during 1997 and 1998 at an experimental field located in Centro de Pesquisas Pecuarias do Sudeste - CPPSE - EMBRAPA, near São Carlos City (47º53' W - 22º01' S), on the "Regional Survey of Fodder Oat" project. This region is classified as Cwa, tropical with dry winter and hot and wet summer being characterized by annual medium temperature of 21,3ºC and annual precipitation of 1520 mm (Brazil, 1987). The temperature data and total rainfall of the years of 1997 and 1998 were collected in the meteorological station of CPPSE (EMBRAPA) close the study area (Fig.1).

In 1997, three *Avena sativa* cultivars were used: UPF 86066, UPF 86081 and UPF 87111. The experimental area comprised five blocks, each one containing the three cultivars in separate parcels. Therefore, five repetitions for each treatment were observed, adding a total of 15 parcels with a surface of 11 m^2, performing 12 rows - 10 useful rows and two borders. Seeding took place in May 26th and twigs started emerging in June 2nd. In 1998, the studied material was UPF 86081, UPF 87111, from the previous year, UFRGS 7, UPF 3, São Carlos (*Avena bysantina*) and black oat, *Avena strigosa*. Twenty-four parcels, of identical size with those used in 1997, were divided into four blocks, providing four repetitions for each treatment. Parcels were sowed in April 4th and first twigs emerged in May 3rd.

Aspersion was used to irrigate the experimental field during the culture cycles, in both years. The area around the site was partially taken by oat crops and partially free from cultivation.

Figure 1 - Monthly medium values of temperature (lines)



maxim (tmax), average (tmed) and minimum (tmin) and rainfall (bars) in the study area during 1997 and 1998 years.

Samples of aphids and their mummies on the cereal cultivars were taken weekly, from June through September of 1997 and from May through August of 1998. These samples were described as days after emerging of twigs (DAE). In order to analyze the influence of the varieties on number of aphids, number of mummified aphids, proportion mummies/aphids and occurrence of parasitoids on the collected mummies, data were classified in three groups: a) before the first oat harvest (0 - 60 DAE); b) after the first oat harvest (61 - 104 DAE) and c) total samples from the cycle (0 - 104 DAE).

Aphids were captured with an entomologic net, while walking around the parcels (Ilharco et al., 1982). The insects were packed in plastic bags and taken to the laboratory, where water and some drops of detergent were added to the material. This material was put in a petri dish and was analyzed under stereoscopic microscope. The aphids were classified according to their morphologic characteristics. Whenever the assembling of aphids was made necessary for microscopic observation, the method of Ilharco (1992) was used.

Mummies were manually collected with a pruner from the 10 useful rows in each parcel, within timed five minutes for each parcel. They were counted and those damaged by emerged hymenopterans, were rejected. The mummies collected in 1997 were kept in plastic bags, while those collected in 1998 were put in test tubes and covered with cotton for easy identification.

Aphids were identified according to Blackman and Eastop (1984) and primary parasitoids following Starý (1976) and Powell (1982). Noyes (1980) was referred to on the hyperparasitoids identification. The occurrence of aphids and their mummies on the different cultivars of oats was analyzed comparing randomly chosen blocks with one-way analysis of variance, with means defined by the Tukey test at a probability of 5% (Zar, 1999).

RESULTS AND DISCUSSION

A total of 706 and 1,143 aphids were collected, respectively in 1997 (12 assessments) and in 1998 (13 assessments). The predominant aphid species found in the experimental area was *Rhopalosiphum padi*, while other species were observed in very low proportion in different years (Table 1). *R. padi* infected the surface of both, the leaves and the apical parts of the plant, as well as its blossoms (Ahmad and Singh, 1994). The community of parasitoids occurring on the oat, obtained by the emergence from 314 (1st year) and 510 (2nd year) entire mummies, comprised three species of the Braconidae family (Ichneumonoidea: Aphidiinae): *Lysiphlebus testaceipes*, *Aphidius colemani* and *Diaeretiella rapae* (Table 1).

Table 1 - Species and total percentage of aphids, parasitoids and hyperparasitoids occurring on the oat culture during 1997 and 1998.

Species	Years	
	1997	**1998**
Aphids		
Rhopalosiphum padi	97.4	98.2
Schizaphis graminum	1.1	1.6
Rhopalosiphum maidis	1.0	0.2
Metopolophium dirhodum	-	0.1
Brevicoryne brassicae	0.3	-
Aphis gossypii	0.1	-
Parasitoids		
Aphidius colemani	54.9	34.2
Lysiphlebus testaceipes	32.0	54.6
Diaeretiella rapae	13.5	11.2
Hyperparasitoids		
Syrphophagus aphidivorus	93.9	34.4
Alloxysta brassicae	6.4	65.6

The first two species were alternatively dominant at the two studied years. *D. rapae* occurred in smaller amounts in both periods. These three Aphidiinae species have been considerably reported in various regions in Brazil, where they parasitized a large number of aphid species (Tavares, 1991).

Two hyperparasitoid species emerged from the collected mummies: *Syrphophagus aphidivorus* (Mayr) (Chalcidoidea: Encyrtidae) and *Alloxysta*

brassicae (Cynipoidea: Charipidae), and different domination was observed in each year (Table 1). Feng et al. (1992) have reported the hymenopteran *D. rapae* and *L. testaceipes* as primary parasitoids emerging from *R. padi* mummies in cereal cultures under irrigation. It was observed that the means of *R. padi* in each parcel did not differ among others cultivars. If the two years of analyses were observed, the cultivar UPF 86081 showed lower rates of aphid infestation than UPF 86066 (Fig. 2).
Population difference obtained from the number of individuals occurring on the various cultivars is one way to verify the resistance of the plants to insects. Therefore, according to our results, through the principle of repetition (Lara, 1991), cultivar UPF 86081 presented higher resistance to *R. padi* if compared to UPF 86066 and to the black oat.
In 1998, UPF 86081 presented lower numbers of aphids than the other cultivars in the first and in the total period (Fig. 2). Robinson (1992) has reported that antibiosis effects, with reduction on the daily production of nymphs, and non-preference, recorded by variety of barley resistant to the aphid *Diurapis noxia*, have not been observed for *Rhopalosiphum padi*.
The means of mummified aphids, per parcel, did not differ among oat cultivars in 1997. In 1998, this number differed among oat cultivars only after harvest (Fig. 2). The period after harvesting showed that the cultivar UPF 86081 presented number of mummies higher than the black oat and UPF 3. During 1997, the larger proportion of mummies/aphids was observed on UPF 86081, in the period preceding the oat harvest and in the total culture cycle, indicating a more effective action of the parasitoids on that treatment.

Table 2 - Mean values ± standard deviation of the percentage of parasitoid emergence on the mummified aphids, for each oat cultivar, observed in all samplings, in 1997 and 1998 in the following intervals: 0 - 60, 61 - 104 and 0 - 104 DAE (Days After Emerging).

Cultivars	Analyses[2] (DAE)		
	0 - 60	**61 - 104**	**0 - 104**
UPF86066 (1997)	70.8 a ± 13.0	61.6 a ± 12.8	66.6 a ± 9.6
UPF86081 (1997)	76.2 a ± 11.6	61.8 a ± 8.0	71.7 a ± 12.4
UPF87111 (1997)	71.4 a ± 15.5	64.4 a ± 10.8	67.4 a ± 9.7
Black oat (1998)	70.1 a ± 10.8	68.8 a ± 9.3	67.4 a ± 8.0
UPF 3 (1998)	79.5 a ± 12.8	74.0 a ± 9.7	75.6 a ± 14.8
UPF86081 (1998)	88.8 a ± 15.6	73.0 a ± 12.1	79.5 a ± 13.9
UFRGS7 (1998)	82.5 a ± 17.4	75.3 a ± 10.3	80.8 a ± 13.6
São Carlos (1998)	80.2 a ± 16.4	71.8 a ± 8.8	76.8 a ± 10.8
UPF87111 (1998)	69.7 a ± 14.4	77.7 a ± 16.0	73.0 a ± 9.8

[1] Original data. These data has been transformed in $\sqrt{x}$ for statistical analysis. [2] Means followed by the same letter in this column have presented no statistical difference on the Tukey test ($p<0.05$).

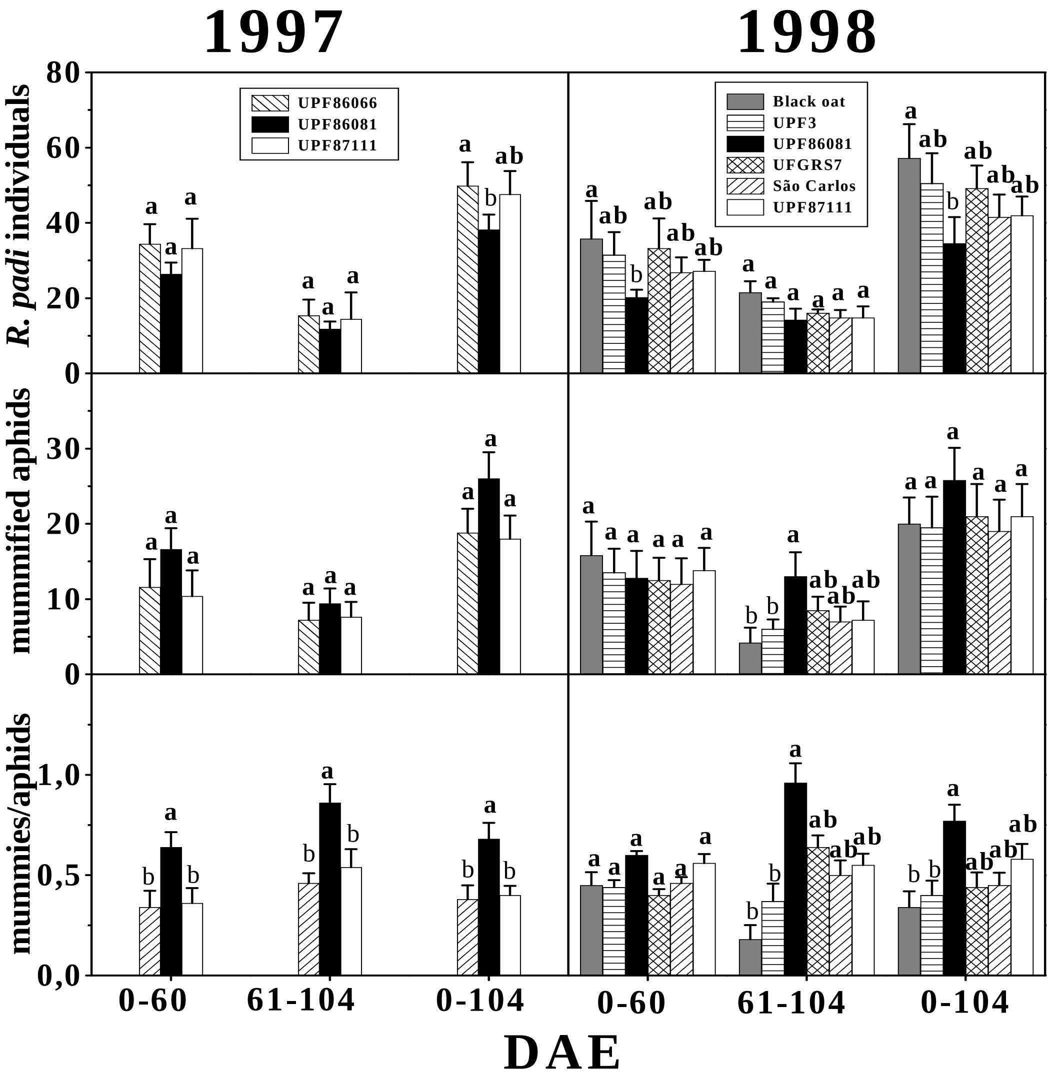


Figure 2 - Average (bars) and standard deviation (lines on the bars) values of number of *Rhopalosiphum padi* individuals, mummified aphids number and proportion between mummified aphids and apparently healthy aphids in each parcel, for each oat cultivar observed in all samplings in the following intervals: 0 - 60, 61 - 104 and 0 - 104 DAE (Days After Emerging) during 1997 and 1998. These data has been transformed in $\sqrt{x}$ for statistical analysis. Means followed by different letter above bars in same age indicate significant difference, on the Tukey test ($p<0.05$).

In 1998, the rates of parasitism did not differ among oat cultivars in the period before the harvest (Fig. 2). However, in the intervals 61-104 DAE and 0-104 DAE, UPF 86081 parasitism was different from black oat and from UPF 3 (Fig. 2). This higher influence of UPF 86081 cultivar regarding the action of the parasitoids observed in both, in 1997 in contrast to UPF 86066 and UPF 87111 - and in 1998 compared to the black oat and UPF 3, may be associated to the resistance to *Rhopalosiphum padi* presented by that cultivar.

The best performance of parasitoids, by parasitism rates, observed in UPF 86081 indicated existence of synergism between plant resistance and biological control of aphids. Farid et al. (1998) have analyzed the impact of varieties of wheat resistant to the aphid *D. noxia* and its parasitoid, *Diaeretiella rapae*. Compared to the sensitive variety, the resistant ones suffered less damage due to the aphid's nourishment, presenting smaller reduction of the leaf surface, weight and height. A higher percentage of parasitoid occurrence was observed on the mummies collected from the resistant cultivars (Table 2). These results suggested that parasitism and plant resistance performed a compatible behavior.

Testing the preference of *L. testaceipes* to the varieties of resistant and susceptible oat to *Schizaphis graminum*, Schuster and Starks (1975), in either release-capture or olfactometer tests, observed rather significant parasitoid response on the resistant variety. Biswas and Singh (1998) reported that there was no evidence disregarding the resistance of plants and bio-control as highly effective and compatible on the integrated handling of pests aiming aphids. In arena tests, Braimah and Van Emden (1994) have used primary parasitoid *Aphidius rhopalosiphi* females obtained from *Rhopalosiphum padi* mummies and testified more egg laying on *S. avenae* on the arenas with wheat leaves than on those with paper filter. This showed how important the chemical stimulus of the host-plant was to the parasitoids acceptance towards the aphid. A similar experiment with *S. avenae* and *Myzus persicae* (Sulzer) presented more egg laying of both parasitoids in wheat, than in other types of plants, again proving the importance of the referred stimuli (Ahmad and Sing, 1994).

Wickremansinghe and Van Emden (1992) have observed the reaction of adult females of parasitoids to volatile chemical stimuli of aphid host-plants. It was found that various species of hymenopterans were more attracted to the smell of the host-plant, or to the honeydew of the aphids - when the plant is absent - than to the smell of the host-aphids, themselves. However, the combination of smells from both, the plant and the aphid, proved to be the most attractive tested stimulus. Therefore, parasitoids have better response to the aphids affected with the volatile elements of the plants, rather than to the pure aphids.

The biology of parasitoids, regarding the emergence of mummified aphids, showed no influence from the difference found on the varieties both in 1997 and 1998 (Table 2). Similar results were reported by Schuster and Starks (1975) in the percentage of hymenopteran emergence on aphid mummies for all treatments in five susceptible varieties of wheat, sorghum, barley, rice and oat cereals.

CONCLUSIONS

1. *Rhopalosiphum padi* was the predominant aphid in oat cultivars;
2. The dominant species parasitizing *R. padi* in the target area were *Aphidius colemani* and *Lysiphlebus testaceipes*, and the hyperparasitoids reared in interaction with those species were *Syrphophagus aphidivorus* and *Alloxysta brassicae*;
3. The UPF 86081 cultivar presented smaller attack of *Rhopalosiphum padi*, compared to UPF 86066 cultivar and to the black oat and reported higher rate of aphid parasitism than the UPF 86066, UPF 87111, UPF 3 and the black oat;
4. The biology of parasitoids, regarding the emergence of mummified aphids, suffered no influence from the different cultivars.

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RESUMO

Foram avaliadas as interações entre afídeos e seus himenópteros parasitóides em cultivares de aveia irrigada, como também a resposta de diferentes cultivares em relação resistência à estes afídeos e a influência nas relações hospedeiro/parasitóide durante dois anos em São Carlos, SP, Brasil. *Rhopalosiphum padi* (L.) foi o afídeo predominante ao longo do estudo, enquanto as outras espécies raramente foram encontradas. Foram observadas cinco espécies de himenópteros parasitóides: três parasitóides primários, *Lysiphlebus testaceipes* (Cresson), *Aphidius colemani* (Viereck) e *Diaeretiella rapae* (M'Intosh) e dois hiperparasitóides, *Syrphophagus aphidivorus* (Myer) and *Alloxysta brassicae*

(Ashmead). A cultivar UPF 86081 apresentou resultados significativos quanto à baixa infestação por *Rhopalosiphum padi* e maiores taxas de parasitismo que a demais cultivares. Não foi observado efeito significativo na variação de porcentagem de emergência de parasitóides nos afídeos mumificados ao longo deste estudo.

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