

Aphid Species and Population Dynamics Associated with Strawberry

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Abstract

Aphids are among the major pests associated with strawberries in Southern Brasil. In this study, we identified the main species that occur in strawberry fields in the states of Paraná and Rio Grande do Sul, Brasil. We also compared the effectiveness of different sampling methods and studied the population dynamics of aphid species during two strawberry crop cycles in the municipality of Pinhais, state of Paraná, Brasil. *Chaetosiphon fragaefolii* (Cockerell) and *Aphis forbesi* Weed were the main species associated with strawberry. The method of hit plant and the Möericke trap showed equal effectiveness to capture wingless and winged insects. The peak population of aphids in the state of Paraná occurred from September to November. This information can help producers to implement strategies to monitor and control the major aphid species that occur in strawberry culture.

Introduction

Cultivation of strawberries (*Fragaria×ananassa* Duchesne) is an important economic activity for small- and medium-sized farms in different producing regions, especially in Southern Brasil (Ferla *et al* 2007). However, constant interventions to control pests and diseases are required (Fadini *et al* 2004) to satisfy the market demand for defect-free fruits. Aphids stand out among arthropod pests that occur in strawberry culture. Large populations of these insects intensify sap sucking, favoring the development of sooty mold (*Capnodium* sp.) resulting in reduced photosynthesis, production, and fruit quality (Krczal 1982, Rondon *et al* 2005, Cédola & Greco 2010). Moreover, aphids are vector of viruses (Rondon & Cantcliff 2004, Rondon *et al* 2005, Cédola & Greco 2010).

Although aphids are considered important pests in strawberry, little is known on the species that occur in the different regions of Brasil. Furthermore, many studies show a national divergence regarding aphid species and their scientific nomenclature. Among the species reported in Southern Brasil, *Chaetosiphon fragaefolii* (Cockerell) (Costa

et al 1993) is predominant, but it was also reported as *Pentatrachopus fragaefolii* (Cockerell) and *Capitophorus fragaefolii* (Cockerell) (Salles 2003). Similarly, *Aphis forbesi* (Weed) was also cited as *Cerosiphia forbesi* (Weed) (Salles 2003). According to Remaudière *et al* (1997), the genera *Pentatrachopus* and *Capitophorus* cited by Hodson (1937) and Salles (2003) are no longer reported in the literature or even as synonymy. Also, the genus *Cerosiphia* cited in the studies by Salles (2003) is considered a synonym for the genus *Aphis* (Remaudière *et al* 1997).

Accordingly, to implement an integrated pest management program for aphid pests, it is crucial to know the species and their population dynamics to identify population peaks and, therefore, define the best time to employ control measures (Miller & Foottit 2009, Henz 2010). It is critical to determine the best sampling method during the strawberry crop cycle to obtain effective monitoring of aphid pests.

Currently, monitoring is performed randomly by observing the presence of aphids on plants in the plant beds (visual identification). Due to the gregarious habit of aphids, this monitoring technique does not show the actual population

density of the pest in the field once colonies of these insects are formed on the underside of strawberry leaves or plant crown, hindering visual identification. Therefore, studies on new effective monitoring methods are necessary to monitor aphids in strawberry, allowing a more accurate density estimate of the pest population in the field. Thus, the objective of this study was to identify the main aphid species associated with strawberry culture in the states of Paraná and Rio Grande do Sul in Brasil to determine the best sampling method of aphid pests and to evaluate the population dynamics of aphid species in strawberry.

Material and Methods

Aphid species associated with strawberry culture

The aphid species associated with strawberry culture in the states of Rio Grande do Sul and Paraná, Brasil, were surveyed during two crop cycles (2009/2010 and 2010/2011). Samples were collected in commercial cultivations of strawberry grown in low-tunnel system.

In the state of Rio Grande do Sul, the study was conducted in 49 commercial areas of strawberry; in the municipalities of Bento Gonçalves (two areas), Caxias do Sul (eight areas), Farroupilha (three areas), Flores da Cunha (three areas), Bom Princípio (eleven areas), Feliz (three areas), Ipê (nine areas), Pelotas (six areas), Turuçu (two areas), and São Lourenço do Sul (two areas) from August 2009 to August 2010. Every month, we collected five leaves from the top of the plant and five petioles of the crown region per plant sampled from 10 random points in each crop totaling 490 samples during the study period. The aphids collected were kept on their own leaves or petioles and transported to the lab in plastic bags (3 L), where winged and wingless insects were screened and preserved in 70% ethanol for later identification.

In the state of Paraná, aphid species were monitored only in the municipality of Pinhais, from March 2010 to March

2011, using chromotropic Möericke traps and the method of hit plant, as proposed by van Driesche *et al* (1998). Traps were deployed in stage of plant growth (first sprouts). The average size of farms was approximately of 0.3 ha. The experimental design was a randomized block in factorial, with treatments consisting of four strawberry cultivars (Albion, Camarosa, Camino Real, and Ventana). During the crop cycle, insecticide was not sprayed for pest control and the management of invasive plants was performed manually. Data on temperature and precipitation were obtained from the Meteorological Station of Pinhais, state of Paraná.

The chromotropic Möericke traps were made with plastic bottles (2 L) by making a rectangular cut (17×14 cm) in the longitudinal direction. The inside of the bottles was painted in yellow and positioned horizontally at the center of the plots among leaves of the strawberry plants at the same height of the plant, transverse to the direction of plots, and filled with saturated water (1 L) and detergent (200 mL). The trap contents were collected weekly with a 0.2-mm sieve and the solution was replaced.

The method of plant hit was carried out with three shakes in the shoot of strawberry plant to capture the aphids (winged and wingless) in a plastic tray (0.25×0.30×0.5 m) lined with white ethyl vinyl acetate paper dampened with water and detergent solution to prevent the escape of insects. The sampling was carried out weekly at random in four strawberry plants along the plant beds.

Species identification

Aphid specimens were prepared on slides following Martin (1983) and identified using taxonomic keys (Costa *et al* 1993, Blackman & Eastop 2000). After species identification, we determined the occurrence rates by using faunistic analysis (Abreu & Nogueira 1989). The aphids captured in Paraná by using the different sampling methods and cultivars were subjected to analysis of variance and means were compared by using the Tukey's test at 0.05% probability (SAS Institute 2009).

Table 1 Aphid species collected from strawberry plants with data on occurrence, dominance and Palma classification. Municipality of Pinhais, state of Paraná.

Species	O(%)	PCO	D (%)	PCD	PGC
<i>Chaetosiphon fragaefolii</i>	52.0	C	68.1	DM	C
<i>Aphis forbesi</i>	25.0	AC	14.5	DM	I
<i>Aphis gossypii</i>	19.1	AC	16.2	DM	I
<i>Myzus persicae</i>	0.3	AC	0.2	AC	R
<i>Tetraneura nigriabdominalis</i>	3.60	AC	1.0	AC	R

(O%) rate of occurrence for aphid species, PCO Palma Classification for occurrence (AC accidental, AS accessory, C constant), D(%) rate of dominance for aphid species, PCP Palma Classification for predominance (AC accidental, AS accessory, DM dominant), PGC Palma General classification (C common, I intermediate, R rare).

Table 2 Aphid species collected from strawberry plants with data on occurrence, dominance and Palma classification. Municipalities in the state of Rio Grande do Sul.

Species	O(%)	PCO	D (%)	PCD	PGC
<i>Chaetosiphon fragaefolii</i>	81.6	C	68.5	DM	C
<i>Aphis forbesi</i>	18.4	AC	31.5	DM	I

O% rate of occurrence for aphid species, PCO Palma Classification for occurrence (AC accidental, AS accessory, C constant), D(%) rate of dominance for aphid species, PCD Palma Classification for predominance (AC accidental, AS accessory, DM dominant), PGC Palma General classification (C common, I intermediate, R rare).

Results and Discussion

Diversity of aphid species associated with strawberry culture in the states of Rio Grande do Sul and Paraná

We identified five aphid species associated with the strawberry culture in the municipality of Pinhais, state of Paraná: *Chaetosiphon fragaefolii* (Cockerell), *A. forbesi* Weed, *Aphis gossypii* Glover, *Myzus persicae* (Sulzer) and *Tetraneura nigriabdominalis* (Sasaki; Table 1). However, when the same study was carried out in different municipalities in the state of Rio Grande do Sul, we observed only two aphid species instead: *C. fragaefolii* and *A. forbesi* (Table 2). *Chaetosiphon fragaefolii* was predominant in both study sites (68.1% Pinhais and 81.63% in Rio Grande do Sul). Similar values were obtained for *A. forbesi*, with intermediate occurrence

of 14.5% in Pinhais and 18.3% in Rio Grande do Sul. *Aphis gossypii* and *M. persicae* showed intermediate occurrence, while *T. nigriabdominalis* had rare occurrence in Pinhais (Table 1). These species were not identified in the study sites in Rio Grande do Sul (Table 2).

We observed greater diversity of aphids associated with strawberries in the municipality of Pinhais when compared to the study conducted in Rio Grande do Sul, as strawberry is cultivated under organic production system in Pinhais. Organic production systems are known to be ecologically balanced and lead to an increased diversity of species (Miñarro *et al* 2009). Furthermore, the non-use of insecticides in the area allowed the establishment of new pests that would be otherwise eliminated or kept at low population densities by chemical applications (Zehnder *et al* 2007).

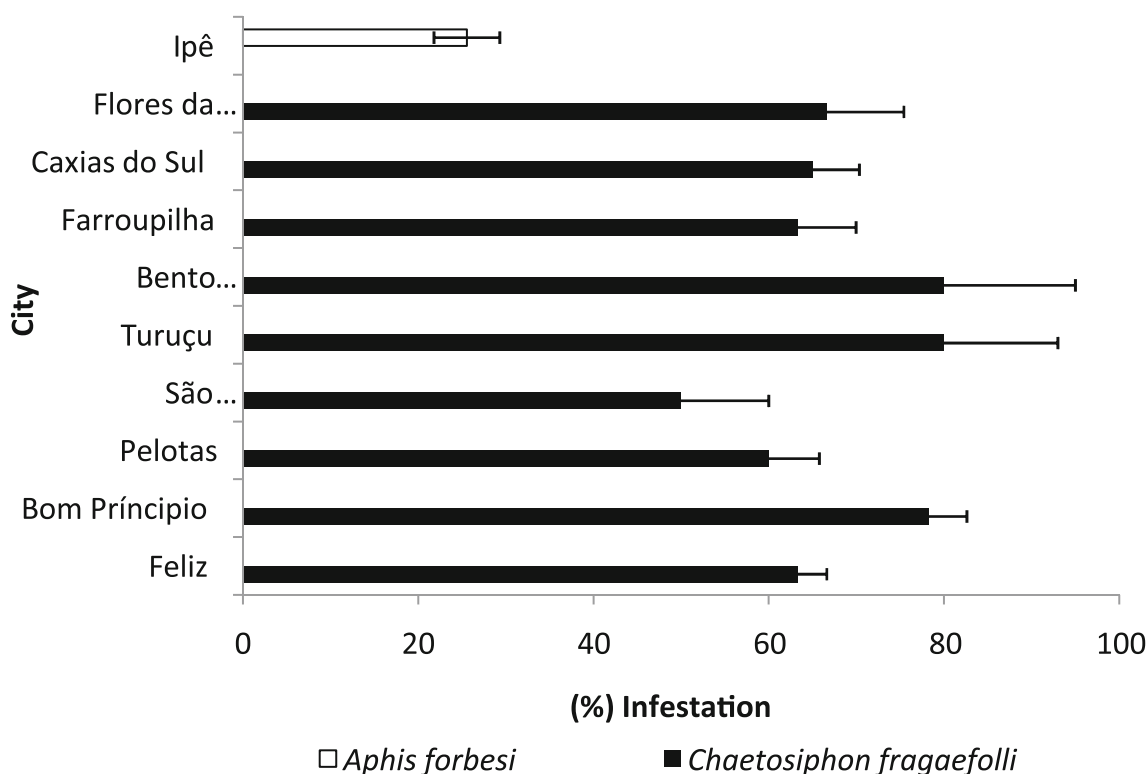


Fig 1 Rate of aphid infestation in commercial strawberry cultures in municipalities in the state of Rio Grande do Sul.

Table 3 Weekly number ($X \pm EP$) of aphids (wingless+winged) captured in strawberry cultivars in the municipality of Pinhais, state of Paraná.

Cultivars	<i>Aphis gossypii</i>	<i>Aphis forbesi</i>	<i>Chaetosiphon fragaefolii</i>
Albion	0.631±0.254 aB	0.548±0.125 aB	2.618±0.529 aA
Camino Real	0.381±0.095 aB	0.598±0.069 aB	1.847±0.309 aA
Camarosa	0.447±0.104 aB	0.601±0.203 aB	2.244±0.461 aA
Ventana	0.319±0.104 aB	0.515±0.060 aB	1.826±0.405 aA

Means followed by lowercase letters in the columns and uppercase letters in the rows did not differ in the Tukey's test ($P \leq 0.05$).

We observed high infestation with *C. fragaefolii* in the different municipalities of Rio Grande do Sul without the occurrence of species overlap in the same crop (Fig 1). *Aphis forbesi* occurred only in the municipality of Ipê (Fig 1), where *C. fragaefolii* did not occur. The rate of occurrence of *C. fragaefolii* in the surveys conducted shows that the pest was constant in strawberry production systems in the different municipalities studied, predominating in 80% of the samples during the study period (Fig 1).

Differences in the dispersion behavior of *C. fragaefolii* and *A. forbesi* in the municipalities of Rio Grande do Sul may have influenced the occurrence of these species in the survey, varying from place to place. The predominance of one or another aphid species in strawberry crops may be related to climatic factors such as temperature, wind, and humidity as climatic factors and diet can directly influence the population dynamics of aphids in cultivated areas (Nickel 1987). *Aphis gossypii* was not observed in Rio Grande do Su

and only rarely Paraná, although existing reports on its sporadic occurrence in Rio Grande do Sul (Salles 2003).

Chaetosiphon fragaefolii was a dominant species in study sites in the states of Rio Grande do Sul and Paraná as it has in the USA, Europe, South Africa, and Argentina (Krczal 1982, Rondon & Cantcliffe 2004, Cédola & Greco 2010). This pest is considered the major insect vector for viruses such as *strawberry vein banding virus*, *strawberry mild yellow edge virus*, *strawberry crinkle virus*, and *strawberry mottle virus* (Krczal 1982, Rondon & Cantcliffe 2004, Cédola & Greco 2010).

In our study, *C. fragaefolii* predominated and showed maximum indices of faunal classification as dominant, very abundant, very frequent, and constant totaling 68% of all insects identified, at both sites sampled (Rio Grande do Sul and Parana), while the others species *A. forbesi*, *A. gossypii*, *M. persicae*, and *T. nigriabdominalis* were classified as intermediate and rare (Tables 1 and 2) with *A. gossypii*, *M. persicae*, and *T. nigriabdominalis* occurring only in Pinhais.

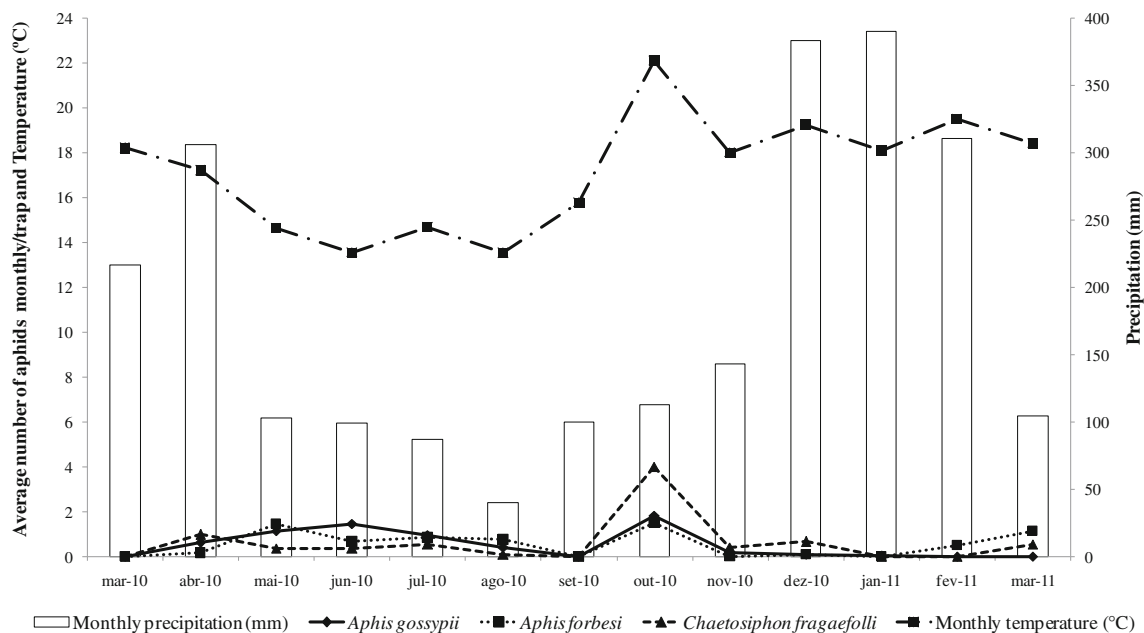


Fig. 2 Population dynamics of aphids (wingless+winged) using the Moericke trap in strawberry culture in the municipality of Pinhais, state of Paraná, Brasil.

Species diversity in four cultivars and population dynamics in the state of Paraná

We did not find significant difference in aphid infestations (wingless+winged) for *A. gossypii* ($F=0.76$; $g.l.=3.571$; $P=0.515$), *A. forbesi* ($F=2.16$; $g.l.=3.571$; $P=0.191$), and *C. fragaefolii* ($F=0.75$; $g.l.=3.571$; $P=0.522$) in the cultivars Albion, Camino Real, Camarosa, and Ventana. Our data showed that the infestation level did not vary during the experimental period regardless of the cultivar and species of aphid (Table 3), demonstrating that insects showed no preference for colonization. Although studies of Rondon et al (2005), Cédola & Greco (2010), and Bernardi et al (2012) indicated differences in susceptibility of strawberry cultivars to the biological development of aphids; this difference was not observed in this study.

Population dynamics of aphids in strawberry culture in the municipality of Pinhais, state of Paraná

Abundance of the three major species of aphids was influenced by climatic conditions (temperature and precipitation; Fig 2) indicating that environmental conditions (temperature and precipitation) are important factors for the development and population dynamics of aphids in strawberry, and can positively or negatively affect the development of these insects (Rondon et al 2005). The study demonstrated that the temperature and precipitation showed a constant pattern in the population growth of aphid species, observing the highest population peaks during lower precipitation levels and higher temperatures (Fig 2), similarly to the studies of Rondon & Cantliffe (2004) and Cédola & Greco (2010) with *C. fragaefolii* in strawberry culture and *A. gossypii* in chrysanthemum cultures (Soglia et al 2002).

In general, we observed low incidence of aphids in strawberry fields with only one population peak (September to November) during the study period, which may be related to the vegetative growth and flowering of strawberries (Rondon et al 2005, Cédola & Greco 2010). In the municipality of Pinhais, *C. fragaefolii* population peaked in October 2010, probably due to a combination of high temperature and low precipitation rates, as well as longer exposure to daylight (higher photoperiod), corroborated with the results obtained in Argentina, where the specie *C. fragaefolii* species was recorded on strawberry plants at two population peaks, with the first peaks in the autumn and the second in the spring (Cédola & Greco 2010). However, the species *A. forbesi* and *A. gossypii* showed higher population peaks during the months of May and July 2010 similarly to the results obtained by Rondon et al (2005), who verified highest abundance of *A.*

gossypii during the spring in strawberry cultivations in greenhouses. This fact may be related to the flowering of plants, leading the aphids to infest the plants in the parts that are more nutritious Valerio and Mexia (2007). Aphid infestation decreased after November most likely due to the low amount of new shoots and to the action of natural enemies (predators and parasitoids; Rondon et al 2005). Furthermore, the colonization behavior of *A. gossypii* and *A. forbesi* species affects the sampling of insects in strawberry plants and, therefore, the estimation of population density once they tend to aggregate in the inner parts of plant crowns.

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